REPORT RESUMES

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NEW INSTRUCTION MEDIA, SELF INSTRUCTION - GUIDED INSTRUCTION AND THE ROLE OF THE TEACHER.
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A 3-YEAR PROJECT DEVELOPED PROGRAMED MATERIALS AND DEVICES FOR THEIR PRESENTATION, AND OBSERVED THEIR EFFECTS UPON THE CURRICULUM. SPECIFIC COURSES WERE PROGRAMED AND TESTED AT THE COLLEGE LEVEL. THEY WERE (1) MATHEMATICS, (2) RUSSIAN, (3) MUSIC, (4) CHEMISTRY, (5) BIOLOGY, (6) RELIGION, (7) GEOLOGY, (8) SPANISH, AND (9) PHYSICS. REPORTS OF SUBPROJECTS ON PROCEDURES AND CONCLUSIONS FOR EACH SUBJECT WERE INCLUDED IN THE REPORT. SEVERAL RECOMMENDATIONS FOR FUTURE PROJECTS WERE INDICATED UNDER (1) GENERAL PROCEDURES, (2) TESTING OF EXISTING PROGRAMS, AND (3) PROGRAM DATA. DESCRIPTIONS OF CONTINUING FUNCTIONS FOR THE FUTURE TO BE CONDUCTED AT THE COLLEGE LEVEL WERE INCLUDED. (HB)

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NEW INSTRUCTION MEDIA

Self Instruction - Guided Instruction
and the
Role of the Teacher

EARLHAM COLLEGE
M. Daniel Smith

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Definition of Terms

Program: A carefully designed sequence of learning situations ("frames") which have been developed to the point where students respond correctly to specific criterion items designed to test the behaviors taught. Ordinarily, programs require an overt response to each frame, and then give information concerning the correctness of this response immediately after the student responds.

Program Development: A process in which the performance of a student or students in criterion situations (and on frames of the program, where incomplete) is analyzed and used to improve the effectiveness of the program. This process is ideally carried out using individual students, with revisions after each trial, and then using small groups. Usually, crucial aspects of each frame are omitted, requiring an overt response on the part of the student: this provides data concerning the effectiveness of each frame.

Teaching Machine: A mechanical device for presenting the "frames" of a program; it allows for the overt response of the student (by write-in or selection of one of several choices), and then presents information as to the correctness of this overt response (either by a student manipulation of controls, or automatically through electronic circuits.)

Programmed Text: Texts which, by their special format, accomplish functions described above under "Teaching Machine."

New Media: Comparatively new devices by which learning situations can be presented to students without the intercession of the teacher; devices which present films, slides, and film strips belong to this category, also T.V., and teaching machines. Programmed texts have commonly been included.

Self-Instruction: Recently understood to be the process by which students use programmed instruction with minimum interaction with professors.

Relationship Between Program Development and New Media: Program development represents an approach to teaching based on thorough examination of procedures and outcomes. While programs are ordinarily associated with teaching machines or programmed texts, program development is basic to all teaching. Thus programming is applicable to all media, although the program-medium interaction is not fully understood in most cases.

Part I

Report of the Coordinator

General Information

This is the final report of a three year project which was supported by a grant from the New Media Branch of the U.S. Office of Education. The purpose of the project was to develop programmed materials and media for their presentation, and to observe their effects on the curriculum. This project was coordinated and directed during the first two years by John Barlow, who is now Professor of Psychology at Emory University. The present coordinator assumed his duties on July 1, 1961.

Support of research by faculty members was provided in the form of "released time;" that is, a portion of the faculty member's salary was paid by the project, and he devoted that portion of his time to program development and testing. The amount of released time varied from none to two thirds; some materials were developed with very little project involvement, others required a large investment in personnel and material. In addition to providing released time, the project provided secretarial assistance and paid for mimeographing and other so-called "office" services. It also functioned as a clearing house for information during the first two years, when little was known about teaching machines or programmed instruction, and when formal channels of communication were not operating as they are now.

The type of developmental research carried on has been a necessary first phase for research in this area. While programming provides a tool for research in learning and teaching, it requires very close integration of subject matter knowledge with models based on learning principles. The construction of programs is a research problem in itself, resulting in added knowledge about both subject matter and the learning of it. Evaluation of outcomes of such research requires thorough inspection of the materials used and data accumulated. Criterion items can be isolated and data from them examined statistically, but a comprehensive view of the learning process can only be gained by qualitative examination of the data from the entire programmed sequence. This is due to the fact that the student not only learns to respond correctly on criterion items, but he also learns to provide the type of behavior which the sequence of frames requires of him; thus, he learns a way of learning and a way of approaching a given subject. It is true that much of this behavior can be reduced to discrimination and generalization paradigms, but this reduction is accomplished on a relatively complex level, where questions related to extent of material per frame and difficulty of mediating behavior must be settled empirically.

A major outcome of this project, then, is found in the materials produced and the equipment designed to present them. General descriptions of each sub-project are given in another section of this report: some samples are found in an Appendix. Since Earlham is devoted primarily to teaching, emphasis has been on incorporation of materials developed into the curriculum. While data have been collected on the programs themselves, they have for the most part been treated qualitatively, and the results have been manifest in the revised versions. Information concerning certain variables has been handled statistically, but this sort of procedure has been limited. Subjective observation by the professors involved has composed the main evaluation process; control groups have not been feasible at this early stage. During the last year of the project, increased emphasis was placed on careful analysis of program data, as well as on pre- and post-testing to ascertain the nature and extent of achievement.

It is often true that a large part of the programming process is tied up in clerical-secretarial-editorial functions: the actual programming is analogous to the visible part of an iceberg, with the functions just mentioned comprising the part below the surface. Thus the provision of adequate funds for released time did not always imply an efficient use of professorial talent, since a disproportionate amount of effort had to be devoted to semi-clerical (though specialized) activities: this applies to the Russian project, for instance, where extensive materials were produced for a considerable portion of the course. On the other hand, where "spot-programming" predominated, it was found that the faculty member involved needed only small amounts for secretarial help: the limited nature of his programming made it possible and desirable to do part of the producing and reproducing, revising, proofreading, and data processing himself, so that he could keep in close touch with the outcomes; this was especially true in Biology, for instance. The ideal situation may lie somewhere between these two extremes, depending on the subject and the inclination of the professor; that they are extremes is shown by the fact that one of the projects required an investment of more than five hundred dollars a month (including salaries of professor ahd clerical help, as well as materials and reproducing costs), where another required about fifty dollars a term. Of course, the extent of materials produced differed tremendously: one project illustrated the feasibility of using self-instruction materials extensively, while the other illustrated that time may be saved using them for very limited areas in the course.

Impact of the Project

It is difficult to evaluate the impact that programmed instruction and new media will have on college curricula from the limited evidence that we have at present. This project was the first to receive support from the Office of Education in this field, and little was known at the time of its inception about the problems of programming different subject matters at this level. Faculty members, expert in their own fields, were somewhat hesitant to apply strictly the prescriptions for programming laid down by Professor Skinner and his associates at Harvard: they felt, with some justification, that the behaviors involved in studying college materials were bound to be highly complex and difficult to analyze and set down step-by-step as demanded by the conditions for so-called "linear" programming. On the other hand, they were inspired by the dedication to control of human behavior through positive reinforcement, affirmed by Professor Skinner in an address to the college: this was in sympathy with the Quaker ideal of finding something of God in every man, but the control of behavior through mechanization was not. This seeming paradox has not been fully resolved on this campus yet. Added to this difficulty was a natural reluctance to change time-tested procedures despite the many factors which press us to do so; it must be observed that this reluctance is a necessary safeguard, since the state of educational evaluation is not sufficiently far advanced to permit us to say with certainty that the new methods and materials are generally better, or that they do not have undesirable side effects.

Acceptance of Programmed Instruction

Despite the difficulties inherent in the task, and despite formidable requirements of time and energy involved in programming subject matter, programmed instruction, and certain new media designed for their presentation, have gained a foothold in the curriculum.

Acceptance among the faculty is limited mainly to programs developed by faculty members themselves, however; programs developed elsewhere have not in general measured up to Earlham's standard, in the opinion of those professors who have reviewed them or used them. This is due partly to differences in point of view concerning presentation of subject matter content. Another part of the criticism is based on the programming itself: in general, faculty members have felt that programs offered for use at the college level have required learning behavior which is not the most desirable kind. In their eyes a program which requires behavior which is less complex than students can produce does not differentially reinforce the most desirable parts of the behavioral repetoire of the student. Such criticisms are valid, but are based upon an incomplete concept of the nature of the behavior which is to be required. Experience in programming often clears up some of this vagueness, and brings the professor to appreciate the control offered by programs. However, many such programs do require behavior which does not seem best suited for future success in the subject. Techniques for adapting programs to different "levels of ability" are at best crude approximations to the ideal, and require additional research. However, these shortcomings are not a necessary attribute of programming, as is shown by programs developed at Earlham which do require desirable learning behavior from the student.

Use of Teaching Machines

In general, "teaching machines" have not gained acceptance at Earlham. Programmed instruction is treated as a highly controlled form of independent study, and the added control offered by machines is not deemed necessary. In the area of languages, however, and also in music, special audio-lingual equipment has been an integral part of the programming enterprise. This equipment is described in detail in another section of this report, and is operationally defined in the detailed account of the Russian project also found in a later section. It was an outcome of collaboration between programmer linguist, research associate, and technical assistant. It was designed to present a particular program in particular modes of student tape-text interaction: this is in contrast to the common machine-first procedure. A prototype of a more versatile piece of equipment has been developed which would be useful to programmers in the future: it makes a variety of functions available to the student through exceedingly simple manipulations. The full potential of this equipment has not been realized, since members of the language department have not had opportunity to become fully conversant with its functions. Additional uses in such areas as Music (beyond present simple functions used already), Speech, and possibly audio-lingual additions to programs now completely textual, have yet to be explored. It is assumed that this equipment will have an important effect on "language laboratories" and other instructional complexes in the future, both at Earlham and elsewhere.

Saving in Time

Since the scope of available programs is limited, and program development slow, no teacher has yet felt the benefits of released time for more personal interaction with students or more careful preparation of lectures, except on a scale too small to be reliable. In some ways, programming has created more problems that it has solved: it has opened up a vast area to be explored, and revealed gaps in our teaching procedure not previously recognized. It does not seem to the author of this report that the time variable is as important as it is sometimes held to be, however; the quality of the educational process is most important, and if additional time should be required in order to get more desirable educational outcomes, it should be spent. We have found that some students take a very long time when given a program, while others go quickly; we cannot compare this with conventional approaches because the subject matter is not the same. Our experience also brings out the difficulty in evaluating the amount of time necessary for program development, especially when this development approaches the ideal procedure including pre-testing, revision on the basis of results from individual students, and then trial on larger groups (with pre- and post-testing to ascertain what actual gains have been made). One programmer (Music) took two months to develop two weeks' work; this "two weeks' work" could have been handled in two days by concentrated study. In Russian the work of a summer (by a team of three people) was covered in a term by a class of sixteen; given sufficient time and equipment, this class could probably have covered the same material in three weeks. (A term is about nine weeks long.)

Reactions of Students to Programs

Students at Earlham are not satisfied with present programs: however, they are enthusiastic about some, appreciate the advantages afforded, and want more. There is of course objection to the approach itself, both with and without machines: part of this is due to the newness of it, part to its nature. A student with highly developed study skills objects to the "straight-jacket effect" of a program: a student who is used to being content with one example of a concept (whether adequate or not) objects to the constant "repetition" of a program rich in experiences which sharpen abstract responses: a student who is used to learning through solving problems objects to the slowness of the approach and to the fact that it eventually leaves him the task of solving the problems himself anyway. Programs often are ill-adapted to the task of setting the student free to do for himself: they take him part of the way but leave him there to flounder.

In many cases students appreciate the help given by programs in particularly difficult areas, just as faculty members appreciate the added effectiveness of the presentation. Often, however, students react negatively, and these negative reactions seem to have several sources. First, a "short-step" program of some length seems to have a cumulative effect akin to boredom or "reactive inhibition"; students find it increasingly difficult to force themselves to return to it, even though they have been responding correctly. This seems to reflect certain sources of difficulty, one of them being the human aversion to being led, another being inexperience with the constant concentration required by the program. A program requires more continuous covert behavior, related to the referents of the words or symbols involved, than does the same material in conventional text format. It seems that programming of a particular subject area results in a more closely knit, systematic presentation, which in turn requires concentration (and provision of complex mediating behavior) closely akin to that commonly required in the study of mathematics or physics; such may not be typical of conventional presentations of this subject, and thus lead to adverse reactions. On the other hand, a program may require mediating behavior less rigorous than that usually required in a given course (especially in mathematics), and therefore appear beneath the student who has adjusted himself to that level. In general, however, it seems that where a program clarifies something otherwise quite difficult, where it provides a convenient means of learning an area which is otherwise difficult, the reaction is favorable: where a program compresses a subject matter which previously was loosely organized or slow-paced, the reaction may be negative. It may be observed here that programs have an inherent pace: no matter how fast a student proceeds he is required to cover the program according to a preset sequence of frames: no matter how slowly the student goes, he is required to furnish a certain minimum of complexity of covert mediating behavior, and this may be beyond his ability to provide. Adaptive techniques hold promise, but have not been adequately developed.

Problems of Programming

In foregoing sections, much has been said about the shortcomings of programs. Not all of these shortcomings are inherent in the process itself: they only reflect our lack of ability to account for and improve the teaching-learning processes. Programs are but models based on certain learning principles, and no program can be said to be the best model. "Step size" is an undefined term; the identity of the reinforcing stimulus (or stimuli) is obscure: the optimal frame size and extent and complexity is undetermined even for limited subject matters. The process of program development, however, seems to hold out hope for the future science of education; this process must be carried out in many subjects many times before we can induce axioms on which better systems can be built. With this in mind, even the limited success of our early attempts, guided by little more than intuition, promise better things to come. Of course, this success is also a tribute to the compensating ability of the students who have used the programs.

Continued Use of Programmed Instruction and New Media

It seems probable that where quality programs of limited scope exist and fit a given course organization, they will be used. In the opinion of this author, the automation of complete courses implies a rigidity of course content which is not in the best interest of education at any level: programs should be subject to a continuous process of revision. However, if such a full course were to be compiled slowly according to the developmental process described elsewhere, and were to be in a continual state of revision of old sections even as new ones were being completed, it might well become a worthwhile tool in the hands of a master teacher.

Continued use of audio-lingual equipment of the type designed within this project is also quite probable, and additional use of certain features of the advanced prototype as well. Consoles which display slides in conjunction with taped and textual materials hold promise for presenting materials both programmed and unprogrammed, but it seems that more extensive programming in various subjects is needed before they are a good investment. This also applies to complex electronic "teaching machines;" there may well be a place for such equipment in the future, if a large enough library of quality programmed material can be provided for them: at present, one cannot justify the purchase of such machines for the limited materials available, especially since their use is not necessary for the presentation of present programs. The major research problem still lies in the field of programming: when programs become sufficiently effective and complex in their formats and in their adaptive features, and when sufficient variety and scope of materials is available, colleges will be justified in purchasing limited numbers for pilot studies. We have not had sufficient experience with them to estimate the parameters involved in this decision-making process.

Role of Educational Institutions in this Research

It has been difficult for faculty members to find the time to produce programmed materials, and harder to devote even a minimum of time to evaluating adequately their effect on the curriculum. Even though released time has been provided, the problems of providing the highest type of conventional instruction in remaining courses are unending. To balance this, however, it seems important that faculty members in institutions such as this be given a chance to devote time to such research. A small private liberal arts college is naturally primarily interested in its instruction, and the later success of its students in both graduate school and other pursuits depends greatly on the excellence of this instruction. It therefore seems fitting that time be devoted to research in the instructional process itself: programming is just one tool for this research, but our experience shows it to be a powerful one. It is in its infancy, and we have just begun to realize its potential. Yet commercial programming tends towards rigidity of format and concept: improvements may not be as likely to come at the rate they should when publishers are intent on producing "conventional" programs (if such a description is possible at this stage) to maintain their competitive position. Thus, we need to keep a group of subject matter experts who are interested in experimenting with instructional sequences, and who are also close enough to the ultimate consumer to evaluate realistically the consumer's reaction and change in behavior, if any. The present concept of programming is, after all, but an early model of the principles of psychology which spawned it; one can hardly expect versions of the future to look exactly the same.

Theory and Practice in Programming

The present coordinator has been interested to find common problems among programmers in various subject matters in the course of consultation with them. The problems of the Russian linguist concerning the learning of conversation resembled the problem of the programmer in Chemistry concerning the solving of problems based on facts and concepts learned in early sections of the program. The problem of the programmer in Music concerning the association of verbal terms with musical sounds and the discrimination between these sounds was similar to those involved in handling the problem of coordinating textual and audio expressions of words in Russian. The problems of learning the meaning of Cyrillic notation, of musical notation, of chemical symbols, and of geological formations were similar to those met in teaching students the concept of variable in Mathematics. Yet, while all of these seem to have common ground in basic principles of learning theory - discrimination, generalization, and their derivatives - and while they may be described in terms such as "transcription," "translation," "abstract response formation," we are as yet unable to predict outcomes or best approaches with any certainty on the basis of these principles. What is needed is extensive experience in the programming of different subject matters - continued attempts to induce general conclusions from these, and thereby to implement theory to the point where, eventually, some effective deductive systems are possible. I do not believe they are possible yet, even in simple situations. For instance, this author has frequently been struck by the difference between a commonly expressed opinion that "teaching machines are ideal for helping students memorize facts...," and his own inability to state any dependable or theoretical framework for achieving the memorization of a group of facts by programming, other than repeating them at intervals and with a frequency, both of which are determined completely intuitively.

Part II

Summary of Activities of the Project

The following brief accounts of sub-projects are given in order to place these activities in some perspective relative to the overall project.

In Mathematics, a programmed textbook was developed which enables students to compute simple descriptive statistics - mean, standard deviation, percentiles - by means of grouping and coding. This will be published, and is available meanwhile through the Project. It has been used regularly in several courses.

In Russian, extensive materials were programmed which coordinate audio-lingual equipment with interlinear-text presentation. During the fall of 1961, the first of three terms in Elementary Russian was taught almost entirely by means of these materials and this equipment: the professor interacted through correction tapes based on student recordings. Subsequent course work has employed self-instruction extensively, but not exclusively. During the fall term extensive data was gathered and a report submitted to the Office of Education. One part of the course, Introduction to the Alphabet through Phonetic Cognates, forms an independent tape-text complex.

In Music, early work concentrated on the presentation of information about musical intervals. During the final year of the project, a program was developed which conditioned abstract responses related to Tone Color, primarily through musical excerpts; textual material carried the thread of the lesson and posed questions based on the music. Examples of this program and a report based on use during the fall term were submitted to the Office of Education. Additional data concerning its effectiveness were collected during the spring term.

In Chemistry, three members of the department have developed programmed material; during the last year of the project this development featured careful analysis of program data and subsequent revision. Some of the material (which is of the limited-extent type we call "spot-programming") can be used independently.

In the area of audio-lingual equipment special circuits using Uher Universal tape decks have been in use since the fall of 1961 and have proved durable and versatile. An all-electronic prototype of this equipment has been redesigned several times, and is the subject of a detailed report being submitted to the Office of Education. Special equipment was also designed and used with the program in Tone Color in Music and has been described in detail in the report submitted at mid-year, 1961-62.

In Biology, review materials featuring immediate knowledge of results were developed and are being used regularly. Programmed sequences, such as the one dealing with cells, have also proved effective and popular. These materials are designed to make use of study skills already developed by the student and frequently are meant to follow certain text assignments and lectures.

In Religion, extensive materials of a "Questionnaire" type were developed to improve the quality of study of the Bible; these materials are not programmed in the conventional sense, but rather they direct the student into effective study behavior of the main text.

In Geology, slides and coordinated taped descriptions were presented by a means which allowed either individual or small group self-instruction. These sequences aided in the formation of abstract concepts concerning rock types and geological formations. These were developed during the last year and proved useful and popular; they are not programmed, however. A commercial audio-visual console was used to present them, and it proved effective. (Graflex Audio-Graphic)

In Spanish, development of materials similar to those used in Russian was undertaken during the summer of 1961 and continued through into the spring and summer of 1962. These materials are being developed using a team approach; the team was directed by the linguist who programmed the Russian, assisted by two members of the Spanish department and a native informant studying at the college. These materials will be used during the coming school year, 1962-63.

In Physics, a short program developed by the coordinator of the project was used during the spring term of 1962; data indicate that it functioned effectively to acquaint students with an area commonly excluded from the curriculum (Hydrostatics and Hydrodynamics).

In the area of programming technique the present coordinator has continued his interest in approaches to mathematics and science; exploratory programming carried on during the year was in sequences in which responses are based on stimuli which are technically verbal, but which do not use words. Experimental programs now being adapted to this approach deal with topics in Vectors, Inequalities, Absolute Values, and certain theorems in Hydrostatics and Hydrodynamics.

Some field testing of programs developed elsewhere has taken place. These programs have proved to be useful but in some cases crude and unadapted to the demands of college level students. At present only one such program of length is in regular use, while two others will probably be used when revised versions come out.

The Project as a Dissemination Center

In a report of the first two years of the project, John Barlow commented as follows:

> More than twenty-five addresses to educational groups have been given by project participants.... The number of visitors has constantly increased....; during some single months the number of visitors has been sixty

> or more.... The project regular mailing list is now something over four hundred....; the number of requests for general and specific information is such that the Coordinator has spent approximately two days each week taking care of them.

By the final year of the project, dissemination activities in this field were being handled by other projects specifically organized for the purpose; thus the present coordinator has limited this phase of project activities in favor of increased concentration on developmental research. However, requests for information still come in at the rate of five to ten a week, and visitors were frequent during the third year.

Continuing Functions

The project has inspired additional work in programming to be carried on during the coming year:

In Chemistry the Chemical Bond Approach group will explore programming of their materials; a full time programmer will consult with a member of the department and with the coordinator of this project. This is supported by a grant from the National Science Foundation.

In the area of Non-Western Studies, as part of a general grant from the Ford Foundation, exploratory programming of Japanese will take place. A native teacher will be in residence during the year to program in this subject; she will consult with the linguist who programmed the Russian course and also with the coordinator of this project.

Workshops in programmed instruction have been conducted by the present coordinator during the summer of 1962, one at Indiana State College and one at Earlham. These were graduate courses, two weeks in duration, and created considerable interest on the part of the experienced teachers enrolled. They featured construction of programmed and evaluation instruments and trials on volunteer students from elementary through high school grades. It is intended that similar workshops will be offered in the future.

During the coming school year, the increasing fund of available programs will be made available to students at Earlham for enrichment and remedial work. This has not been possible previously due to the very limited extent of materials available.

Part III

Reports of Sub-Projects

1. Howard Alexander and Roland Smith-Statistics:

Professor Alexander has commented at length on the program in statistics and his discussion is reproduced here:

"In the summer and fall of 1959 work was begun on a program in Descriptive Statistics at Earlham College, for use in connection with the course in Elementary Statistics. Howard Alexander and Roland Smith collaborated in producing the program. Two large reasons led us to choose Descriptive Statistics for this first venture in programming. First, it was felt the Descriptive Statistics could just as well be learned by students outside of class, thus freeing class time for topics of greater ultimate significance. Descriptive Statistics is here understood to include such topics as frequency distributions and their graphical representation; various measure of central tendency and of dispersion; percentiles; the interpretation and the applicability of these various descriptive devices. When the instructor is no longer burdened with the need to deal with these topics in class, he can give his primary attention to deeper matters, such as probability and statistical inference. The second reason for the choice was that it was anticipated that if all students in the class in Elementary Statistics were to use a program in Descriptive Statistics toward the beginning of the course, then some of the distressing heterogeneity of the class might be removed. This has indeed been our experience. A further dividend is that each student is able to proceed at his own speed through a body of material which will be very easy for some, quite difficult for others.

The first version of the program in statistics was mimeographed on 4 x 6 cards. A typical unit would consist of about 20 cards, each bearing some material to be studied at the top, with questions and computational tasks interspersed. The answers to these questions appeared on the bottom inch of the card. The cards were placed in a simple cardboard rack, made from a manila folder, with a flap at the bottom to cover the portion of the card bearing the answer. In actual use, the student would read the material at the top of the card, write down his answers on a sheet of paper, then remove the card and compare his answers with those on the bottom of the card. After checking, he would proceed to the next card.

The program was extensively revised during the spring of 1960. All items on which three or more errors were made in a class of 30 students were revised, either by removing ambiguities, or by expanding into several items. The revised program was printed by Earlham College during the summer of 1960 in two forms: (a) the set of 4 x 6 cards already described; (b) a workbook, in which the items are arranged serially down the 8 1/2 x 11 page, each item followed by its answer. When using the workbook, the student needs only a piece of cardboard to mask the answers. The program has since been used, tested, and revised during the academic year of 1960-61 and 1961-62. Performance on the program has never been used for grading purposes. Instead, its use has been followed by a series of achievement tests given in class. The results of these tests have been incorporated in the final grade. The program is now in process of being published by D.C. Heath and Co.

The program prepared by Howard Alexander and Roland Smith is not far removed from a textbook in style. It differs from a textbook chiefly in that the material is subdivided into relatively small portions, and the student is immediately tested as to his comprehension of the essential matters in each portion. In this way, the student can be confident at each stage that he is in command of the material.

As a result of our experience, I would say that programming is likely to be most efficient if one is able to begin with a clear idea of the outcomes, in terms of performance, that one would like students to achieve by means of the program. Thus a good place to begin would be the construction of a set of achievement tests, covering in detail all the goals of the programming effort: the terminology, the concepts, the skills of analysis, the computational algorithms, perhaps even the skill in proof that we expect the student to have achieved. The construction of the program is then a matter of building a series of small steps which lead, without any gaps, toward the pre-established goals. In this process, the feed-back one gains as a result of student experience with the program fulfills an essential role: it enables one to judge whether, in fact, the sequence is gap-free and unambiguous, and whether the pace is satisfactory. Thus program construction is a highly collaborative enterprise, in which the user plays an essential part.

Students have been asked to evaluate their experience with the program by means of anonymous questionnaires. The results indicate that they have enjoyed the use of the program, and have felt that their retention was better than with a textbook. On the whole, student performance on the achievement tests has been quite satisfactory.

Professor John Barlow, who has used the program in connection with a psychology class at Emory University, comments, "I used the program during the Fall term and found it very well received by the students and quite effective in communicating the material covered." Professor Roland Smith comments as follows on his experience in the Winter term at Earlham College: "In general, I think the program gave the class a good knowledge of Descriptive Statistics quite efficiently, especially considering the wide range of interest and ability among the more than forty students."

In the spring of 1961 an experiment was conducted to test the relative effectiveness of several modes of presentation of the program in Descriptive Statistics. The program was published, in the summer of 1960, in what is sometimes described as "vertical format;" that is, questions and answers were printed in succession down each page. Many researches contend that the vertical format is inferior to the horizontal format, or programmed book, in which the first question appears at the top of the first page; its answer appears at the top of the second page; the second question appears at the top of the third page; its answer appears at the top of the fourth page; and so on. After the top portions of all pages in the book have been used, the student turns back to the beginning of the book, and follows through a series of items at the second level of each page.

Many of the features of the experiment about to be described were conceived by John Barlow and John Gilpin. In addition to the comparison of the horizontal with the vertical format, it was decided to investigate such additional questions as the following: (a) is the student helped or hindered in his learning by the requirement that he write out his responses? (b) is it helpful to use a "scanning device" which completely covers the portion of the page below the point at which one is working? (c) is it essential that the student be required to formulate, for himself, the answers to the questions proposed by the program, or is it sufficient that he observe these answers, properly emphasized? In order to investigate questions such as these, the following four modes of presentation were used in the experiment:

A. Programmed book Precisely the same material as in the published program is here typed in the horizontal format, referred to above.

B. Scanning book The material, in vertical format, is inserted in a loose-leaf notebook. A plastic scanning device is used with the notebook, which covers the material below the point at which the student is working.

(Note: In the experiment, students using modes A and B were required to write out their answers; students using C and D, described below, were not required to do any writing.)

C. Workbook The material, in vertical format, is bound in the form of a workbook.

D. Answers supplied The material is typed in vertical format. However, instead of leaving blanks for the words or numbers to be inserted, these are filled in, using capital letters in the case of the words, for emphasis.

The subjects for the experiment were 16 male freshmen at Earlham College. The Quantitative Score of the Scholastic Aptitude Test of the College Entrance Examination Board was used as a measure of mathematical background. Of the 16 men, 8 were selected at random from the upper quarter of Earlham's freshmen in regard to Quantitative Score, while the remaining 8 were selected from the lower quarter. These two groups of 8 men each will, in what follows, be referred to as the "High Q" and the "Low Q" groups, respectively.

The 16 subjects were assigned to 8 experimental groups, according to the following schedule:

	Write answers		Do not write answers	
	Programmed book	Scanner	Workbook	Answers supplied
High Q	2 subjects	2 subjects	2 subjects	2 subjects
Low Q	2 subjects	2 subjects	2 subjects	2 subjects

The subjects were induced to participate by being told that they would be paid approximately $2.50 for a little more than two hours as subjects. Just before they started to study they were told that they would be paid according to the scores they obtained on a test after they had finished studying the material. All subjects were permitted to take as long as they wished to complete the material, which consisted of the first four Units of the program in Descriptive Statistics. They then took the test, and were paid according to the number of correct answers obtained. Several weeks later they were given a delayed post-test, in order to measure the retention of the material studied.

Tables I, II and III give the results of the test administered immediately after the experiment. Table I gives the average score for each experimental group of two subjects. Table II gives the average time taken by each experimental group, and Table III gives the "efficiency," obtained by dividing average score by average time. Similarly, Tables IV and V give the average scores and the efficiencies on the delayed post-test.

A number of conclusions are suggested by these results:

1. The scores are remarkably constant for all 4 methods of presentation. The only exception is that the Low Q group seems to be at a definite disadvantage in using the "Answers supplied" format. These remarks apply to the results of both the immediate and the delayed post-tests.
2. The 4 methods, as presented in the tables, are arranged in order of decreasing time required: Programmed book, Scanner, Workbook, Answers supplied. In the first two of these methods the increased time is in part explained by the requirement that the student write out his answers.
3. On both immediate and delayed tests the efficiencies do not vary markedly for the Low Q group. For the High Q group, the efficiencies are notably higher when the subject is not required to write his answers, and are highest for the Answers-supplied format.
4. This experiment gives no support to the contention that the Programmed Book format is superior to the "vertical" format.
5. The experiment strongly suggests that for the good student, a well-organized book is as effective as a self-instruction program. For the poor student, the book may be less effective than the program. Note, however, that we are here dealing with a "book" which is organized with particular care from the learning standpoint.
6. A comparison of Tables I and IV seems to suggest that retention of learning is best when the answers are written out. However, when

a careful test of significance is applied to the data, this conclusion is found to fall short of significance, at the 5 % level.

Conclusion The self-instruction movement certainly constitutes one of the most intriguing developments in educational technique. The present experiment confirms a conclusion toward which earlier experiments were impelling us: the greatest significance of self-instruction may, in the long run, turn out to lie in the emergence of a new technique for the writing of textbooks. The indisputable fact is that most of our texts in mathematics are marred by conspicuous gaps in the reasoning. In some cases, such gaps are necessary in order to stimulate independence of thought on the part of the student; in other cases they evidently interfere with learning. The analysis of the written responses of students provides a method of "feed-back" which, if conscientiously used by the program constructer, will enable him to eliminate all gaps in the exposition which impede learning.

Table I: Scores, out of possible 21, Immediate Post-test

	Write			Read
	Programmed book	Scanner	Workbook	Answers supplied
High Q	16.2	19.0	18.8	19.8
Low Q	19.0	18.0	17.5	15.0

Table II: Times, in minutes, Immediate Post-test

	Write			Read
	Programmed book	Scanner	Workbook	Answers supplied
High Q	126.0	115.0	45.0	32.5
Low Q	160.0	119.0	108.0	70.0

Table III: Efficiencies, Immediate Post-test

	Write			Read
	Programmed book	Scanner	Workbook	Answers supplied
High Q	.129	.165	.418	.610
Low Q	.119	.165	.162	.214

Table IV: Scores, out of possible 21, Delayed Post-test

	Write			Read
	Programmed book	Scanner	Workbook	Answers supplied
High Q	15.5	19.2	14.8	16.8
Low Q	18.0	15.2	15.8	10.0

Table V: Efficiencies, Delayed Post-Test

	Write			Read
	Programmed book	Scanner	Workbook	Answers supplied
High Q	.123	.107	.328	.515
Low Q	.112	.128	.147	.143

Professor Roland Smith has also commented on the place of programming in mathematics at Earlham as follows:

> Another aspect of self-instruction is the possibility of using it in Earlham mathematics courses or for independent study programs developed elsewhere. Since the basic freshman-sophomore mathematics sequence needs rethinking and consolidation next year, following a considerable upgrading this year, 1962-63 would be an appropriate time to explore the relevance of self-instruction and other teaching aids. At present there are a number of "rough spots"... caused partly by deficiencies in the text...also by the inherent difficulty...and students' lack of experience.... One involves inequalities and absolute values...; a second is the concept of limit (probably the delta-epsilon definition).... If such materials exist, they would probably be used mainly as supplementary reference and possibly to save some class time....

A program in inequalities and absolute values should be ready for use this fall, in response to Dr. Smith's comments.

2. M.Keith Myers-Russian:

The following description of work in Russian is taken from a longer report submitted to the Office of Education. It described work done during the fall of 1961, and does not include work done during the second and third terms of this last academic year. A description of the audio-lingual equipment will be found in another section of this report.

Procedural Details

A programmed workbook was used to introduce students to Russian. This workbook was cast in a grouped, four-line format. It used four hundred thirty-eight Russian words presented in four forms: normal printed Russian, Russian italic, Russian manuscript, and the English equivalent. Through the use of this workbook in conjunction with taped materials the student learned to do the following: (a) comprehend the Russian words when heard, (b) recognize these same words in normal printed Russian, (c) pronounce the words using both audio and textual stimuli, (d) recognize the words when presented in Russian italic, (e) recognize them when they appeared in Russian manuscript, and (f) write the words in Russian manuscript from dictation. Of these types of behavior, (a) and (b) were tested by requiring translation into English; (c) was evaluated on the basis of a tape prepared by the student after he had brought himself near a predetermined criterion on his own (feed-back was provided by means of a correction tape recorded by the professor); (d) and (e) could serve as a confirming response if the student moved the grid upward so that the English word was revealed; similarities between Russian and English cued correct responses to Russian textual or audio stimuli.

These self-instructional materials were used in a special self-instruction center with unique equipment designed for their presentation. This equipment was designed to make possible the complex interaction between student, professor, and workbook which is described in following sections of this report. Students did their course work in the self-instruction center where this equipment was set up; although classes were held during the early part of the course, some in a conventional language laboratory, the course was entirely self-instructional during the last six weeks of the ten-week term (this term was the first of three terms during the school year; students take three courses each term).

Students were required to exceed a predetermined score on progress-tests designed to cover each learning step in the workbook; thus achievement was more a matter of time than of degree of mastery. Results indicated that achievement was consistently high and that individual paces differed markedly. The progress-tests over the first few subsections of the workbook returned data indicating group means of above ninety-five per cent, although the criterion level was not set that high.

Classwork during the first part of the term was mainly conversational in nature, English being used only for instructions as to procedure (classwork did not affect the initial progress-test results mentioned above). Once classes were discontinued, each student proceeded at his own pace, and conversational material was learned through self-instructional processes.

In addition to the conversation tapes, there were also materials related to formal pronunciation training and reading materials taken from a published text but recast in four-line format and accompanied by tapes.

In Step One of the introductory workbook, the student learned to recognize the spoken and printed forms of the Russian words. He did this by using the workbook and tape in conjunction; the criterion behavior was translation from Russian to English. However, since the program is made up of loan-words and cognates, translation was not the primary objective but rather was involved with the means. The program used the spoken Russian form, often similar to the equivalent English word, as a cue to the pronunciation of the printed Russian word, and proceeded from the familiar to the unfamiliar in a gradual way which surprised some students by its simplicity. Any exceptional, non-representative situations learned in this process seem to be justified by the results obtained; care is taken later in the course to rectify any possible incorrect conclusions.

The equipment used to present the audio part of the program allows the student to repeat words or groups of words with great ease; one level accomplishes both start and rewind, and forward motion is automatically reestablished after rewind. The resources of this equipment are more fully des ribed under "Step Two," and later under "Conversations."

During Step One progress-tests, given after every other unit of the workbook, made it necessary for the student to master small portions of the materials before continuing; we feel that this mastery of limited materials is preferable to allowing students to cover large amounts without evaluation. Results from these tests show that all students learned to translate from both audio and textual stimulus. They also indicate a large spread in time needed for preparation. Pretest data show that a few students had studied Russian before.

In Step Two of the introductory program, the students were required to record their pronunciation of the words which they had learned to translate in Step One. As criterion behavior, the student used the printed Russian as stimulus and recorded his pronunciation on a blank tape provided for this purpose. To practice, he used the blank tape for recordings of his own voice, with the master tape version serving to confirm his trial. His own recording could be followed immediately by a rerecording of the corresponding part of the master tape, thus allowing him on playback to make a more objective comparison of his own pronunciation with that of the model, or it could be an uninterrupted series of recordings (interrupted in actual practice recording, however, by the confirming but non-rerecorded master tape playback). When the student reached what he considered mastery of the pronunciation, he recorded his final product and the professor evaluated it; after this the professor rerecorded the student's mistakes, preceding and following each with a correct version and usually adding comments designed to assist the student in correcting himself. The student then practiced further, and finally recorded a test-tape; if this was satisfactory, he went on to Step Three.

Some difficulty was encountered by two students who skipped Step Two and proceeded to the next step. On the other hand, one girl who had had no previous Russian had only a three per cent error rate on her first pronunciation tape in Step Two (438 items). Experience with the program indicated that it would be advisable in the future to break Step Two into shorter sections for more immediate feed-back from the professor.

One additional aspect of Step Two involved the requirement that the student spell certain of the test words as well as pronounce them (these words were selected so that the entire alphabet was used); thus the students learned the names of the letters of the alphabet.

In Step Three students repeated the behavior in Step Two, but using the printed English version as a stimulus; they were also required to spell the Russian, thus demonstrating an ability to spell correctly (this spelling behavior did not prove to be too great a task for most students since the sounds of the particular words aided in analyzing them into their component letters, and thus prompted the correct spelling).

A part of the final step in the introductory program, carried on along with the procedures already described, consisted of tracing the Russian manuscript found on the fourth line of the program text, and spelling the words out loud while so doing. In this way, the student practiced

Russian manuscript for the dictation which was given as the final progress test in the program.

Conversation Tapes

Students carried on work in conversational Russian at the same time they were covering Steps Two through Six of the introductory program. Conversation tapes were accompanied by a printed text in a four-line format; this printed material gives a phonetic re-spelling (as a guide to pronunciation), the normal Russian spelling, a literal translation, and a translation of idioms into acceptable English (including words omitted in Russian). Translations of individual words or phrases are dropped after five or ten occurrences; this "drop-out" is signalled by a superscript number one, indicating that the translation will appear only once more, or by a zero, indicating its last appearance. Footnotes provide alternative words and phrases. Words for which the translation has been "dropped out" appear on the page opposite the last appearance of their translation, accompanied in most cases by a reference to a high frequency Russian word declined or conjugated in an identical manner.

The tape version presents the dialogue with cues to mark the end of one person's speech and the beginning of the second person's response, so that the machine can be stopped easily between them. Alternative responses are also recorded, e.g., "good morning" for "good afternoon." By a series of self-paced learning procedures each student learned to participate actively in the conversation and to change constructions to suit different occasions; he presented his final product in the form of a tape which had his version of first one part in the dialogue, then the other, the professor's voice being rerecorded in each case to provide the other person. Feedback came by way of a correction tape similar to the one described earlier in connection with Step Two of the introductory materials.

In order to make clear the complex interaction between student, professor, and equipment, the following detailed description of the procedure used by one student is present (this is probably representative, although different students emphasized one or another aspect as they found it necessary).

> The student picks up both a conversation tape and a blank practice tape from the secretary in the adjacent office. The conversation tape is put on the "master program" tape deck, and the blank practice tape is put on the "student recording" tape deck. The conversation tape has a two-person dialogue with both parts played by the professor. The student listens through the conversation, looking at the text materials to get a general idea of what is being said (students also find it helpful to spend some time prior to this studying the materials in the text alone in order to have a preliminary knowledge of the vocabulary and the nature of the conversation). After listening to the conversation and learning it to the point where it is intelligible without the text, the student then begins to learn to take an active part in the conversation. He re-

records (onto the student tape) the voice of the professor giving the first speech by the first person in the dialogue. Then he stops the machine and, using the text as a prompt when necessary, records his response as the second person. This is done for the five or more consecutive exchanges in the simple dialogue. The student can go back and listen to the recording on the student tape, which now has a rerecording of the master tape version of the first person and a recording of his own responses as the second person. It often happens, however, that the student is already aware of mistakes he has made and therefore tries again without playback. It seems that this is not a wasteful process, because the fact that the student is recording creates an imaginary audience, which makes the process more realistic than if the student were not recording his response. In later steps, however, the ability to check his own response in juxtaposition with the master stimulus, and also the master version of the response, seems to become more important. When the student feels that he has made some progress in responding as the second person, in that he is able to do so without using the text as a cue and with what seems to him acceptable pronunciation, he varies the procedure. This time he records the part of the first person and rerecords the master tape version of the second person. By the time he has completed this step, he has nearly memorized the entire conversation, and the need for the text as a prompt has decreased considerably. He then records his performance, repeating both persons from memory, and submits his tape for evaluation and correction by the professor.

Formal Pronunciation

Another aspect of the course dealt with learning problems related to Russian pronunciation in general. In one sequence the student was given a printed page having to do with the pronunciation of Russian vowel sounds. On this page the phonetic respelling (or transcription) of a Russian vowel sound was presented on the first line, the phonetic respelling of a Russian word exemplifying this vowel sound was given on line two, and on the third a line-drawing or number was presented - this served as a stimulus for either the Russian word or the vowel sound in question. On the fourth line the English equivalent was presented to insure correct interpretation of the line drawings. The students thus had a set of key-words which were used subsequently by the professor to aid in the correction of mistakes in pronunciation. In the pre-self-instruction phase of the course the students were given this page to study and then were given a practice test in which they were required to print the Russian vowel symbol when they heard the Russian key-word pronounced; after this they were required to make a line-drawing or write a number on hearing the vowel sound alone. On the practice test the mean error percentage was twenty two per cent; on a final test two days later the mean error percentage was seven per cent. A similar procedure (adapted to "self-instruction") was used for diphthongs and consonants and was tested as part of the final examination. Spelling rules, programmed in "linear" fashion for previous versions of this course, may be revised and introduced later in the year.

Reading

Reading materials, consisting of a four-line adaptation of lessons one through nine of Basic Russian by Domar, also made up a part of the course.

The first lesson was treated in class and conventional laboratory before classes stopped; after that, although the materials were made available as soon as they were produced, no further assignments were made until most of the class had finished the workbook and could write in Russian. Then the class was given an assignment over the first nine chapters, to be tested by dictation on the final examination.

This dictation consisted of Russian sentences composed of "drop-out" words from lessons one through nine. The dictation was then translated by the student from his own Russian manuscript. On this, as on all other sections of the final examination, if the student did not reach criterion, he will be required to retest early in the second term.

General Considerations

The various aspects of the course described above were carried on simultaneously. After the first three weeks of the term, the course was devoted entirely to self-instruction, and the students used the special equipment in the self-instruction center. Certain materials, scheduled for use by the majority of students in the second term, were reached by one student in the first term. These include an adaptation of Readings in Russian History by Leon Stilman (with four-line format and "drop-out" procedures similar to those described previously in connection with the conversation materials), and a sequence on life in the Soviet Union coordinating slides, text, and questions concerning the text. They also include a presentation of the original text of Lermontov's Taman', with accompanying tapes; this has a three-line format, the phonetic respelling having been omitted. Also, during the second and third terms, Part II of Basic Russian by Rebecca Domar will be used to introduce a systematic study of Russian grammar.

While problems arose due to the fact that each student proceeded at his own pace, it is felt that the high standards which each was required to meet on each section of the course made up for these. All students but one covered the material successfully, although in different amounts of time; grades were given on the basis of material covered relative to the deadlines set, as well as for relative achievement. Three students in the class advanced to the point where they stood out from the rest; when the material from Domar was assigned (as described above), they had completed all other work and thus were able to concentrate on the Domar. The most advanced of these three had not had formal instruction previous to this course, although the final examination on Taman', completed the written and oral work over Stilman's "Readings in Russian History," and was advanced to a literature course.

The following data are excerpted from the full report as an example of the kind of data collected:

Grades for Post Test: Part C

Possible 72 points

Pre-test Scores - Sept. 25, 1961		Post-test Scores	Date
70	Dolan	71	10/16/61
65	Cooper	68	10/28/61
66	Goldstein	71	11/3/61
0	Bonifer	71	11/20/61
0	Morris	71	11/20/61
0	Mueller	71	11/20/61
0	Lissitz	70 1/2	11/21/61
3	Stevenson	70 1/2	11/21/61
0	Conlon	72	11/21/61
66	Allan	71	11/22/61
0	Smith	69 1/2	12/4/61
0	Lloyd	70	12/4/61
0	Hopps, David	70	12/5/61
67	Shair	71 1/2	12/5/61
21	Locker	68 1/2	12/7/61
0	Hopps, Susan	66 1/2	12/8/61

Complete Data, Pre- and Post-Tests

Test	Pre-test Mean and S.D.		Post-test Mean and S.D.		
A	9.25	*	16	*	(16 possible)
B	5.6	*	16	*	(16 possible)
C	22.4	*	70.2	*	(72 possible)
D	31.5	33	88	2.6	(90 possible)
E	12.5	20	46	2.3	(50 possible)

* S.D.'s for A, B, and C are omitted since the complete distribution is given on previous data sheets.

Note: Most of the words used in D and E are ones which do not appear during the course.

3. Leonard Holvik-Music

Programming in music during the first two years of the project was in the area of musical intervals. During the summer of 1962, Professor Holvik developed a program in Tone Color which emphasized the use of musical excerpts to teach the abstract responses involved; textual materials on cards carried the thread of the lesson and posed questions related to the excerpts heard on tape. This program, as well as the previously programmed material in intervals, was used by large classes in Introductory Music during the year; pre-tests and post-tests were administered to determine a rough base-line of improvement for comparison with later years, and a special group covered the program under more careful control during the spring term. A report on the first experience, including a description of the special tape equipment used, was submitted as part of the project's mid-year report. The general outcomes are described by Professor Holvik as follows:

> Experience confirms our earlier conclusions:
>
> 1. The material is covered efficiently, allowing class time to be used for other things.
> 2. For the series which is relatively polished, (Tone Color) student reaction is excellent and results are superior to those obtained formerly in the class time then given to the subject.
> 3. For the series which is less-well-done, (Intervals) results are not as happy, though superior to former classroom method.
>
> We will continue to use this method, hoping to improve these two programs, to program other parts of the course, and to profit from experiments elsewhere, so as to increase the amount of material covered by programmed lessons.

The following description is excerpted from the full report mentioned previously:

Role of the Program in the Course

Students entering Earlham's "Introduction to Music" course typically display backgrounds varying from 10 years or more of music lessons to complete musical naiveté. This fact, coupled with classes of 50 to 80, has made it difficult to pace the early lectures of the course in such a way as to use the time of the more advanced students to advantage without losing members of the less experienced students by the wayside. The present program in Tone Color is an attempt to deal with part of this problem. The instruction is individualized and self-paced and takes place entirely outside the classroom. Its aim is efficiently to bring all students to an acceptable level of knowledge and perceptual competence in the area of tone color and traditional media of performance. There is much emphasis on standard combinations, chamber as well as orchestral, and on such ideas as "concerto," "solo," "accompaniment," etc.

Program

The program consisted of seven lessons, as follows

Part A	Introduction	22 cards	16 minutes of tape		
B	Strings	30 cards	35 minutes of tape	5 pages	
C	Woodwinds	25	38	of auxiliary	
D	Brasses	18	28	2 mat.	
E	Percussion	24	25	3	
F	Keyboard Instruments	16	28	2	
G	Vocal Music	16	32	3	

The tapes consisted mostly of carefully selected musical excerpts (from well-known compositions) which were designed to display in completely clear fashion the tone color phenomena which were the subject of the program. The cards were used with the tapes, and contained constructed-response self-instruction items relating to the tapes (and, on occasion, to the auxiliary materials which accompanied all lessons except A and C). The auxiliary material for each lesson (except A and C), was read before starting on the tape and cards. The program is a "first draft."

The auxiliary material for the whole program was worked on separately, either before, interspersed with, or after the main material.

Parts A and B had short pretests designed to allow the student to decide whether or not he needed to go through the materials in those parts.

The cards were standard 5 x 8 inch card stock (dittoed). The taped material was on "extended play" tape on 5 inch reels (tape times are estimated, and are running times only, not student use-times).

Auxiliary material to the entire program included a commercially available, humorous book depicting the instruments of the orchestra being played: McKinney, Laurence, People of Note, Dutton, New York, 1960; three pages of material on "Media of Performance" (Appendix III); a record: Britton, Benjamin, "Variations and Fugue on a Theme of Purcell;" and the chapter on Tone Color in Copland, Aaron, What to Listen for in Music, New York, McGraw-Hill, 1957.

The program and its related materials is considered to constitue about one twentieth of the 3 1/3 credit hour course.

Equipment

A special tape recorder* equipped with good quality headphones and a simple relay control circuit was used to present the audio portions of the program.

A touch of a Start-Stop button starts the machine. Another touch of the Start-Stop stops it again. A signal on the tape (which closes a switch in the Akustomat which is in parallel with S/S) also will stop it. Pressing Rewind button causes the machine to back up the tape as long as the button is held down. If Rewind is pressed while the tape is moving forward, the forward motion is interrupted, the tape backs up as long as Rewind is held down, and the forward motion resumes (after a momentary complete stop) when Rewind is released.

The 20-cycle stop-signals on the tape stand out prominently as 200-300 cycle "chirps" when the tape is rewinding, so that the beginning of a passage is easily found.

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* Gilpin, John, "A tape recorder for instructional and other behavioral research," Journal of the Experimental Analysis of Behavior, 5 (1), p.4.

Students

The Introduction to Music class which used the Tone Color program consisted of about 80 students, from freshman through senior classes, and with a very wide range of musical and general backgrounds.

Conditions of Use

The Tone Color program was used during a period of about eight days during the first two weeks of the course. A room containing 5 equipment set-ups was made available to the students from 8 a.m. until 10 p.m. Sign-up sheets allowed students to reserve machines in advance. The assignment was considered analogous to the use of reserve books in the library, and no attempt was made to keep track of actual student work. The post-test grades were counted toward the course grade.

Results

The following test data are based on a random sample of 19 from the class of 80.

Part A (Textual stimulus)	Pre-test (83 possible) Mean 33.5 (40.3%) S.D. 10.5	Post-test (83 possible) Mean 67.6 (81.4%) S.D. 5.4
Part B	Pre-test (82 possible) Mean 38 (46.3%) S.D. 8.2	Post-test (104 possible) Mean 71 (68.2%) S.D. 5.4

Discussion

The test scores achieved, especially for Part B. are in some measure disappointing; the most likely explanation is that students were deflected by the crowded machine schedules, and simply did not go through the materials.

Since the program was used in a classroom rather than an experimental situation, no comparative data are available. In the opinion of the instructor the class was at least as competent in the area of tone color as classes of other years, and he intends to use the materials in the future. Use of the program relieves the instructor of the need to deal with tone color, and frees a number of lecture hours for other purposes.

Results from Spring Trial

During the spring term, a special group of students was observed more carefully while using the programmed material. Their performance on the post-test indicated that they were a representative sub-group; the data collected concerning individual members of the group indicated that at least some of the variability in results was due to differences in amount of and attention given to the programmed materials.

4. **O.T. Benfey, W. Stratton, G. Bakker-Chemistry:**
Work in Chemistry has been of a limited-extent special-subject nature, and can be described best through the reports of those involved. A report by O.T. Benfey covers the work in general and his own programming in particular.

Benfey, O.T.: The most common procedure for preparing programs at the moment is as follows:

1. The separate items are written or typed on pages of 4" x 6" paper pads.
2. The program is checked by one to three students.
3. The program is checked by one or more chemistry colleagues.
4. The program is revised, possibly rechecked, and mimeographed in linear sheet form.
5. The mimeographed program is distributed to chemistry colleagues.
6. It is submitted to one or more classes for testing.
7. Error rates are computed and plotted and erroneous answers listed.
8. Items are analyzed and revised (usually expanded) in light of test results.

Other devices:

(a) Pre-test: given to students to determine how much of the material in the program is already known, or what level of preparation students have reached.

(b) Post-test: given a few days after the program is completed. Given with or without warning.

(c) Questions on examinations, given at the usual times, and examinining the students on materials taught through programs.

Some general comments on programming activities in the Chemistry Department

1. Reactions by students to programmed instruction seem to be predominantly favorable. Our students have had programs presented to them in small doses when particularly appropriate, which may account for the favorable reception.

2. Only linear programming demanding written responses has been attempted so far. We are beginning to see places where extensions in case of difficulties might be indicated.

3. We have found programming so far most satisfactory in very tightly knit subject matter, connected by logic, arbitrary rules or both. Correct word answers seem to be elicited with greater difficulty than numbers, symbols, formulas and proper names (as in naming systems). If one can generalize from our experience one might predict that linear programs with written responses are likely to be most successful with mathematical topics or subjects that can be put in symbolic form, i.e. that are amenable to the approaches of modern algebra.

4. In the original alkane program the final questions were largely missed. They demanded the knowledge from all parts of the program. In the revision an attempt was made to lead more slowly and systematically to the most complex problems. The results were about the same as before. The combination of many items of learned information in the proper order seems to be a learning problem in itself, which needs to be programmed. If this is incorporated in the program, the latter will, however, become rather long. Some alternative approaches perhaps need to be explored.

5. Perhaps it should be noted in the final report that Jay A. Young began his programming activities as a consultant to the Earlham project. Through his article in the Journal of Chemical Education, 38, 463 (1961) he has introduced linear programming to the chemical teaching profession. He is organizing a symposium at the Fall 1962 meeting of the American Chemical Society on Programmed Instruction at which the Earlham work will be described by one of the Earlham chemistry faculty members.

6. One piece of programmed instruction seems to have been a complete success. Instruction in the calculation of "formal charges" in molecules led to 21 out of 23 correct responses to each of two questions in an unannounced post-test and 100 percent correct answers to a formal charge question on a subsequent final examination. This compares with previous years' experience that about half the students at the end of the course did not know how to calculate formal charges. The alkane-naming program also seems to have helped considerably judging from data from a recent examination.

The chemistry staff is noticing the considerable significance of test data on programs and revisions. We therefore feel that it would be helpful if in the next two years we could have available some funds for continued secretarial help and for materials. We see little possibility for utilizing released time next year but may do so the year after.

Stratton, Wilmer: Another member of the department involved in the project was Dr. Wilmer Stratton, who commented as follows:

Objective: To develop a series of programs on selected topics which can be particularly useful in second year chemistry courses at Earlham. Emphasis has been placed on topics which involve semi-mechanical operations or calculations (needing practice and repetition), rather than on complex expository development. Each program is a fairly brief, discrete unit and designed in sofar as possible so that it can be used by itself.

Although the original intention was to prepare programs which could be reproduced as single units, it now appears that they might logically be grouped together and could perhaps - with the addition of 3 or 4 more units - be published as a single volume. Such a volume might be used as auxiliary study material in many second year analytical chemistry —

courses. Most of the topics are ones which are introduced in first year courses, but often not really "learned" until they are needed in analytical chemistry or even later. Such a set of programs might also be useful as auxiliary material in a number of first year courses.

Future Plans for Programming: Further topics which may be programmed as time permits include: acid-base equilibria, solubility equilibria, pH, and modern theory of electrolytic solutions.

One possibility which appears quite promising is to program several brief units of what might be called "case studies" of particular equilibrium systems. A typical program of this type would lead the student through a presentation of some experimental data, a hypothesis as to the nature of the equilibria involved, the derivation of equations which could be used to test the hypothesis, and finally asking the student to make the appropriate calculations and any necessary graphs. The objective is not for the student to "learn" the details of the system of the calculations, but rather for him to be able to work his way through the calculations and to appreciate the logic involved as an example of what can be done. The final steps of calculating and graphing should be quite satisfying to the student.

General Comments:

1. The use of reasonably short programs on specific topics would appear, on the basis of student and faculty comments, to be the most useful approach to chemistry programming. This means that programs would not replace a conventional text entirely, but would replace the text (or possibly used in conjunction with the text) for certain topics. I am sure there is something of a "change of pace" feature involved here.

2. Closely related to the above is the fact that topics of a more mechanical nature appear to be the best suited to programmed presentation, although this hypothesis needs further testing.

3. Student comments on programs seem to be generally favorable. There is some complaint about the tediousness of working clear through a unit. Yet in spite of this, students apparently feel it is a useful technique because they have been asking for more units on other topics with which they have difficulty -- such as equilibrium and activity coefficients.

4. We have been experimenting with various formats for programs, including two columns with answers on right, two columns with answers on left, and a single column with answers directly under each question. Student comments vary and we have reached no conclusion yet as to a preferred form. Further experimentation is in order.

Bakker, G.: Additional comments by G. Bakker are also of interest:

Purposes: The original intention was to develop programs for use in the laboratory of the introductory chemistry courses, and then to program some of the elementary materials in the courses. After the Chemistry 11 and 12 laboratory was rather thoroughly analyzed and several programs were written, it was decided that the laboratory material needed rather drastic revision. The decision was made partly on the basis of the analysis carried out, and partly as a result of what had been learned about laboratory work in the CBA Project.

The main work carried out this year has been the writing and testing of programs covering some of the introductory material in Chemistry 11. Programs of this sort could be useful in two ways. Students who had not had high school chemistry would thus be able to bring themselves up to the level of those who had. And those who had had high school chemistry would get a fresh approach to ideas they already knew something of and, in addition, they would have a clear, logical development of these ideas on which a solid college chemistry course could be based.

Presumably these programs could find use in some high school chemistry courses and most college chemistry courses, and would help chemistry instructors in their efforts to build on the introductory material. All too often the further development of ideas in a chemistry course is seriously hampered by an incomplete or incorrect understanding by the student of the beginning ideas.

Mechanics: The procedure used in writing the programs is essentially that outlined by O.T. Benfey in his report. There are several comments about this procedure which should be made. First of all, the pre- and post-program tests which ought to be given so as to obtain data have not been entirely successful since they do not really give sufficient information. If longer tests are not suitable for brief programs, then the tests must be revised or else given only after sufficient programmed material has been covered.

Secondly, it is normal to wish to know if the students learned specifically the material covered by the program. This presents a difficulty since, in the Chemistry Department, we prefer to test students on their use of learned material, or whether it can be applied elsewhere. Thus a student will either face a different kind of test on programmed material than on other sections of the course, or else the tester must somehow devise a test which satisfies both requirements. This is a problem on which work needs to be done.

Finally, it seems to be of considerable significance to have students working on a program which is suited to them. The student must have meaningful, useable definitions of the terms which are used without explanation. Thus, it is helpful to identify for the student such terms where they first appear. In this way, the student who has difficulty can see where the difficulty arises. He is not merely left frustrated by a confusing frame, but can begin to see where his lack of knowledge is and can therefore act on it. In addition to using many terms strange to a layman, the chemist uses these terms and others in strange ways. Thus there is a difference in the very sentence structure of a chemist speaking to other chemists as compared to a chemist speaking to beginning students. Not only do the terms and ideas of a chemist need definition, but his use of them needs description or experience. It is not at all surprising that W.J. Stratton's program on oxidation-reduction (a freshman chemistry topic) written for sophomores was unsuccessful with freshmen. The jargon used by a chemist is a study in itself. Our experience with programming has only made this more obvious.

Comments:

1. The students generally reacted favorably to the use of programs and wished for more. We will try to satisfy that wish.

2. Since it has been our experience that the programming of logically coherent material proceeds best, I would like to see an attempt made to program material which is logically complete and at a more advanced level of chemistry. I do not think the programming technique should be limited to the presentation of rules and mechanical procedures.

3. The evaluation of a program is a difficult and subtle process. It involves much more than rewording a question or adding a frame where a high error rate is observed.

4. The CBA Project will have a chemist here next year, Walt Hunter, who will be spending full time on the programming of the CBA test. If any of these programs are ready soon enough, I would like to use them in the freshman chemistry courses.

5. I still feel that there is a real problem raised by writing a program with the intent of making it suitable for both bright and dull. It should be possible to devise some means for students to truly move at their own rate.

5. John Gilpin, Robert Warner-Audio-Lingual Equipment:

It has been evident for some time that the production of teaching machines was far ahead of program production; since its inception, the project has addressed itself to the task of filling this gap, and has given only secondary attention to hardware. There is, however, an important exception to this rule: it lies in the area of presentation of audio materials and the accompanying active oral participation in the learning process by students. In the area of Music, the primary interest has been in making repetition of taped excerpts simple and reliable, in order to enable students studying the program in Tone Color (and also in Intervals) to review frequently without difficulty. In the area of languages (primarily Russian), the task has been more complex. Equipment has been in constant use over a period of a year now which enables a student easily and reliably to review short passages of tape, to record both master tape and his own voice, to rerecord at will; these functions are described in the report on Russian given in another section of this report.

The music equipment was designed by John Gilpin, research associate for the project. The language equipment was the result of collaboration between M. Keith Myers (linguist and programmer of the Russian course), John Gilpin, and Robert Warner (technical assistant to the project). It is partly the result of experimentation with a more versatile all-electronic prototype designed by John Gilpin; this prototype has been through at least three major revisions. A pilot project using the first version justified additional work which led to subsequent changes. While not completed in time for use in the concentrated self-instructional Russian course in the fall, it has been used by several students since, and promises to spawn simpler versions for everyday use in specific tasks in the future. On the next page is a schematic of the switchbox for the equipment in regular use at present.

The following resume has been written by John Gilpin: It describes a general purpose piece of equipment designed by him to explore the instructional value of a wide range of audio self-instruction techniques. Its functions are simple to learn, easy to use, and fully adaptable to individual requirements.

Basic design concepts

The use of two independent tape machines, one for presenting the lesson material, the other for recording and playing back material received either from the lesson machine or from the student's microphone.[1] This separation eliminates the constraints on listening-recording flexibility which are imposed by dual channel equipment.

The use of fully remote-control tape machines, which may be operated in complicated patterns by relay control circuits[2]; the use of patch-cord wiring, which allows the control circuits to be modfied or expanded with a minimum of trouble.

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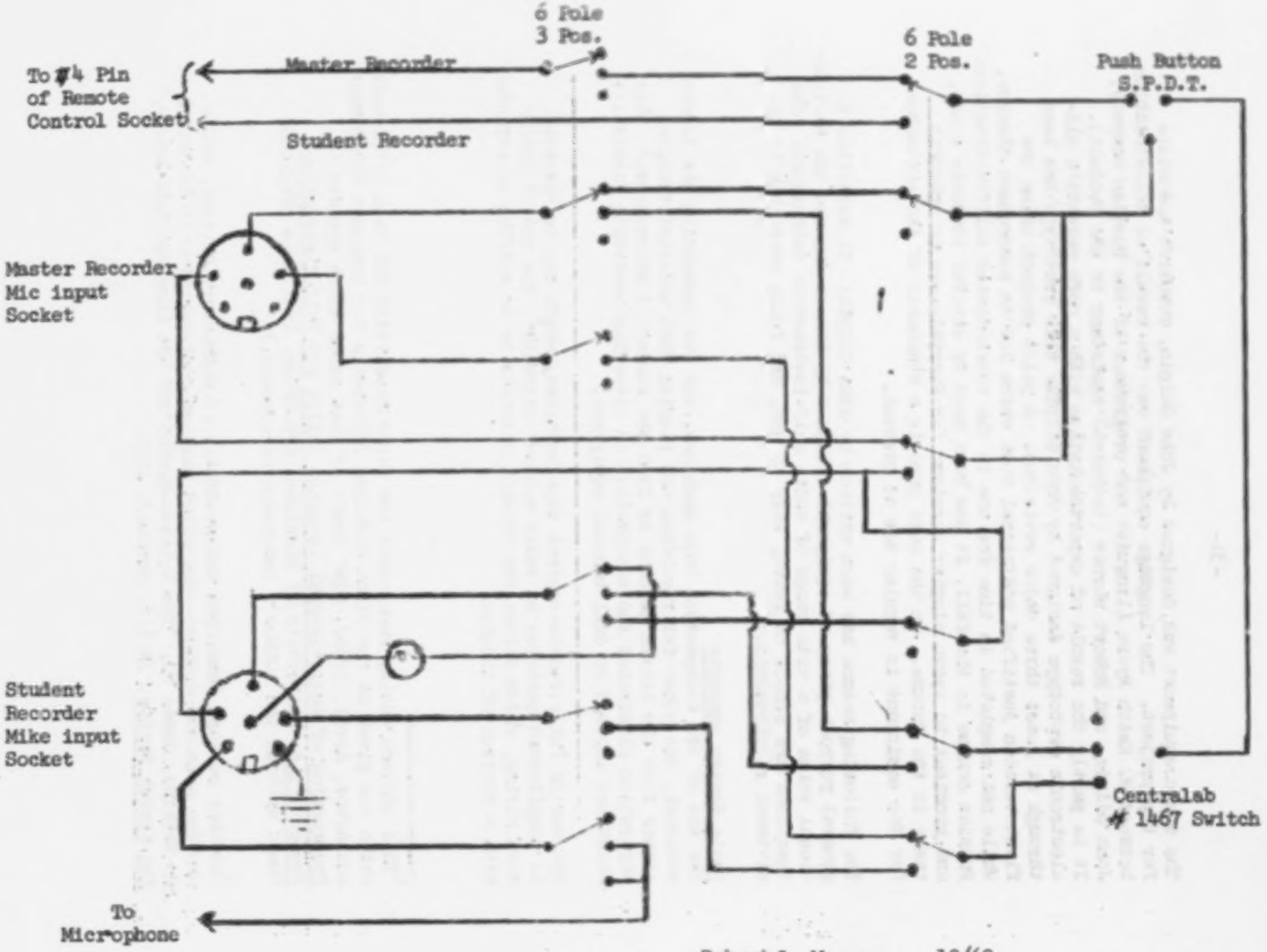
[1] This account wholly supersedes the paper describing the Mark I Polyaudio which was given at the First Michigan Conference for Language Programmers Ann Arbor, April, 1961. (The draft of that paper which appears in Programming of Audio-Lingual Language Skills for Self-Instruction Presentation, University of Michigan, Ann Arbor, 1961, was published there without the author's knowledge or consent.)

[2] Another set-up, developed independently at Middlebury College, which employs a Lesson machine--Recording machine configuration is described in Watkins, James M., "The Library System and the Language Laboratory," The French Review, 34 (1), October, 1960.


6 Pole
3 Pos.
6 Pole
2 Pos.
Push Button
S.P.D.T.
To #4 Pin
of Remote
Control Socket
Master Recorder
Student Recorder
Master Recorder
Mic input
Socket
Student
Recorder
Mike input
Socket
Centralab
# 1467 Switch
To
Microphone

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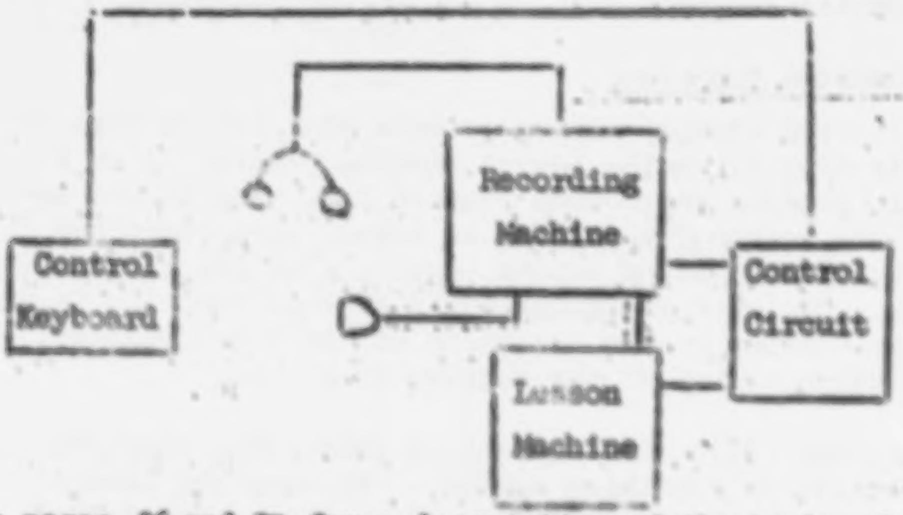
The use of indexing signals on the lesson tape to divide each lesson into passages[3]; the use of a second 'level' of indexing to make the beginning of each lesson when there are several lessons on one tape. These indexes contribute greatly to increasing the versatility of the equipment, and to simplifying its control.

The use of a detached and specially-designed control keyboard, somewhat like that of a 10-key adding machine, in conjunction with circuits which minimize the amount, and complexity of the keying required to carry out the various functions.

Simplified block diagram



See pages 36 and 37 for a description of the keyboard.

Two examples of comparison of the Polyaudio with conventional equipment

The Lesson machine is playing at normal speed. The student wishes to repeat a word or phrase. On a conventional tape machine (eg., Viking Bell) he must:

Stop the tape;
Rewind;
Stop the tape;
Start the tape.

On the Polyaudio he must;

Press the Rewind key and release.

---

[3] Reliable detection of indexing signals when the tape is running at fast forward and fast rewind speeds is a problem which was first encountered during the development of the Automatic Stepwise Tape Recorder, an apparatus designed to provide automatic passage repeat. (Automatic passage repeat is one of the functions of the Polyaudio; see page . A brief (and somewhat inaccurate) description of the Automatic Stepwise Tape Recorder is given in Kopstein, F. F., and Isabel J. Shillestad. A Survey of Auto-Instructional Devices, Aeronautical Systems Division Technical Report 61-414, Wright-Patterson Air Force Base, Ohio, September, 1961. The cheap, simple, and reliable detection circuit developed for the Automatic Stepwise Tape Recorder and later applied to the Polyaudio is based on an approach originally suggested by Mr. James Rice of the Bell Telephone Company of Pennsylvania. Several relays of the sensitive type required by the circuit were generously donated by the Bell Telephone Laboratories.

The student wishes to record a passage, then play it back. On conventional equipment he must:

Turn the Record amplifier to Record;
Start the tape, speak;
Stop the tape;
Turn the Record amplifier off Record (important);
Rewind, watching the index counter or the amount of tape on the take-up reel;
Stop the tape;
Start the tape, listen to the recording.

On the Polyaudio he must:

Touch the Self Only key, speak;
Touch the Automatic Playback key, listen to the recording.

Four examples of advanced functions

Lesson-finding (K'): The student wishes to work with lesson Five on tape II. He threads tape II on the Lesson machine, dials '5' on a telephone-type dial, presses the Search Forward key. The Lesson machine fast forwards to lesson Five, slows to normal play speed and announces "lesson Five," then stops at the beginning of the first passage of lesson Five. The most important yield of this function is in positioning the tape exactly at the beginning of the first passage, ready for the initiation of any of the complex functions.

Automatic passage repeat (D_1'): The student is practising comprehension, pronunciation, dictation or something similar. He uses the Lesson Start/Stop key to start the Lesson machine, which plays one passage, then stops automatically. A touch of the Search Backward key causes the Lesson machine to rewind to the beginning of the passage, then start and re-play the passage. At the end of the passage the tape stops as before, and the student can elect either to play the next passage or to repeat the just-heard one again.

Listen-Record-Compare-Correct (N): The student is refining his pronunciation of some phrase or sentence. He presses Self Plus and hears the phrase as it is recorded onto the Recording tape; a second press* stops the Lesson machine but allows the Recording machine to continue; the student repeats the phrase into the microphone, then presses Automatic Playback and hears both the model speaker and himself; he listens to the comparison as many times as he feels necessary, then interrupts the comparison with the Record button and corrects his own response. This process of comparison and correction continues until the student is satisfied.

Self Only (Q): The student is making a tape to turn in to the instructor for evaluation. His task is to make appropriate replies to a series of given passage. He presses the Self Only key and says his name and the number of the text, presses again to hear the first item to which he is to reply, presses* again and makes his reply, presses again for the second item, presses* again and makes his reply, etc. When he is finished, he presses the Automatic Playback key and hears his own replies only which were recorded one after another on the Recording tape.

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* With the apparatus in the Active Mode (N') this is accomplished automatically.

* With the apparatus in the Active Mode (Q'), this is accomplished automatically.

Tentative conclusions from working with the Polyaudio

In comprehension and pronunciation work it is much more efficient for the student to work with a single passage, listening and repeating until he masters it, than it is for him to go through an entire series before returning to the beginning of the series.

The use of student recording can contribute to the perfection of pronunciation in some students provided that the student can work with a single passage in the manner of the Listen-Record-Compare-Correct function described above.

The ability to adapt practise to personal needs and to accomplish practice easily--without unnecessary operations or attention to the equipment--contributes significantly to student motivation. The effect seems to correlate with perception by the student that he is in control of the machine rather than being controlled by the machine.[4]

These conclusions point to a need for change in the equipment in our "language laboratories." The next section discusses several possibilities.

Equipment for the classroom

Since the Polyaudio is a general purpose piece of equipment, it is overelaborate for routine instructional use. There are several derivatives of it which we have found useful.

The Lesson machine alone; since the student normally needs to record his own voice only a small proportion of the time, fewer than half of the student stations in an installation need to be able to record. This simplification reduces the control circuits of the Polyaudio by about one third, and reduces the number of keys on the control keyboard from ten to four. A pre-amplifier for the microphone must be added.

A simplified Lesson machine; this can be as simple as one cares to make it. The functions that should be retained are easy start/stop, and pause/rewind. The control circuits can use either relays (2) or ordinary mechanical switches. This costs less than $10 beyond the cost of the tape machine.

A simplified two-machine set-up; simple Recording, Self Only, Self-Plus, and Conversation functions can be provided by mechanical switches, eliminating both the detached keyboard and the relay control circuits of the Polyaudio. This set-up trades human-engineering advantages and versatility for reduced initial cost.

An excellent apparatus for classroom use has been assembled by Fernand Marty of Hollins College and described in a report issued by him.

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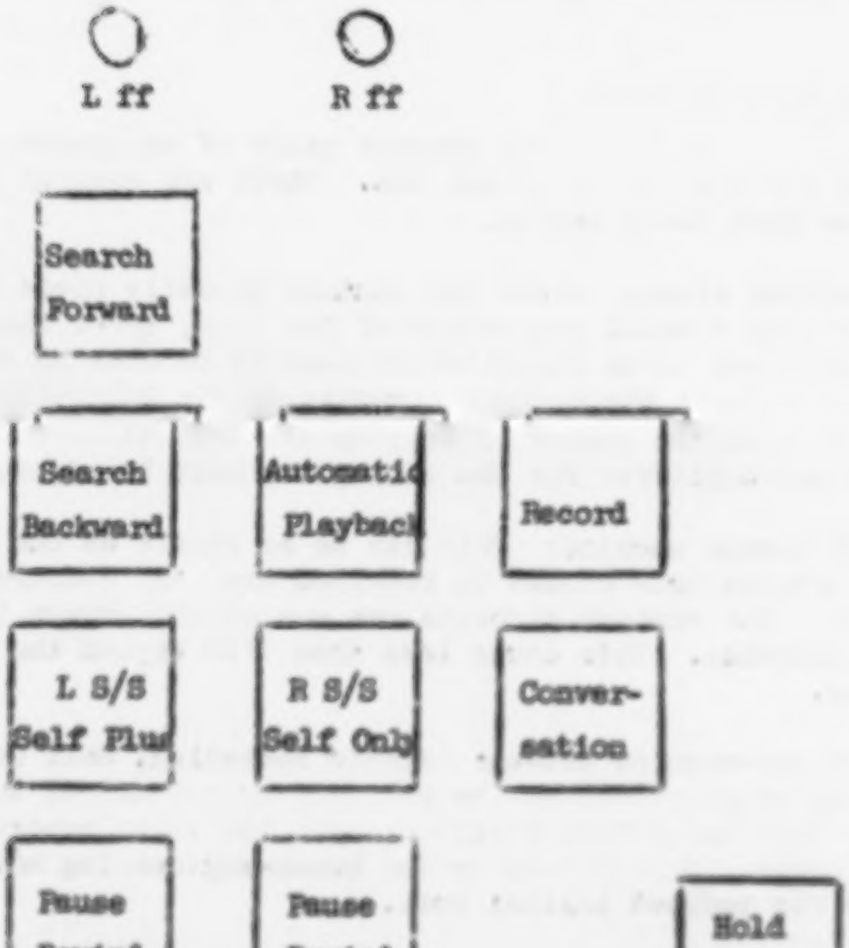
[4] We have successfully used a Norelco dictating machine "typewriter control" accessory for this purpose. A form of "simplified Recording machine" can be obtained by providing the student with an Uher Model 602 Remote Control Microphone.

A Viking '65' reel-to-reel cartridge tape transport and a separate endless loop transport are used.[5] This apparatus has the limitation that it requires material which is divided into passages which are all approximately the same length, but the advantage that its design involves much less wear and tear on the transports than does the Polyaudio. It has simple controls, costs about the same as conventional "language lab" equipment, and will fit in a standard "language lab" booth.

The optical sound track filmstrip which has been developed by the Kalart Company uses a moving light beam to scan a still sound track which is recorded photographically on a frame of standard 35mm filmstrip. Since the optical scanning process can repeat a passage of any length (up to the 18-second capacity of a frame) indefinitely with no mechanical wear on either the projector or the film, this device would seem a very promising candidate for "Lesson machine" in some future apparatus. The problems standing in the way at the moment are the limited frequency response of the present optical recording process and the lack of complete remote control of the film in the projector.

The Keyboard


L ff
R ff
Search Forward
Search Backward
Automatic Playback
Record
L S/S Self Plus
R S/S Self Only
Conversation
Pause Rewind
Pause Rewind
Hold Clear

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[5] Marty, Fernand, Programing a Basic Foreign Language Course: Prospects for Self-Instruction, Hollins College, Roanoke, Virginia, 1962, p. 39.

This keyboard is designed for left-handed use by right-handed people whose right hands may be busy with other things. The hand is "home" with the first two fingers on the Start/Stop keys and the thumb on the Hold/Clear key.

The cabinet has a low silhouette and the front panel slopes like that of an adding machine. The two fast forward keys, infrequently used, are located on the back panel over the peak of the cabinet.

The keys are not labeled on the keyboard as they are on this diagram. The student learns the keyboard by color-and geometry-cues with the help of a keyboard chart similar to that used in teaching typing. On this chart and on the keyboard, the Record key is red, the Start/Stop keys are white, and the Hold/Clear key is yellow. The others are grey.

Of the ten keys on the keyboard, all but three have two positions--i.e., pressing lightly actuates one switch, while pressing further down brings in a second. This not only reduces the number of keys and simplifies the control circuits, but also allows keys to be combined in a logical way which makes the keyboard easier to learn. The actions of the keys are described on the opposite page.

Search Forward: Pressing the key lightly to the first position causes the Lesson machine to fast forward to the nearest passage index; pressing it all the way down to the second position causes the Lesson machine to fast forward to the nearest lesson index.

Search Backward: Analogous to Search Forward. The first position rewinds the tape to the nearest passage index; the second position rewinds the tape to the nearest lesson index.

Lesson Start/Stop: The first position starts the Lesson machine if it is at rest, stops it if it is going. The second position initiates the Self Plus function.

Lesson Pause/Rewind: The first position causes the Lesson machine to pause if it is going; the second position causes it to rewind.

Automatic Playback: This is a single-position key which is used to terminate any function involving the Recording machine. It clears the control circuits, causes the Lesson machine to stop if it is going, puts the Recording machine out of Record, rewinds the Recording tape, plays the recording back.

Recording Start/Stop: The first position starts the Recording machine if it is at rest, stops it if it is going. The second position initiates the Self Only function.

Recording Pause/Rewind: The first position causes the Recording machine to pause if it is going; the second position acts much like Automatic Playback, except that, instead of rewinding the Recording tape to its beginning automatically, it only rewinds it as long as the key is held down.

Record: This is a single-position key which causes the Recording machine to go into Record. It does not affect tape motion. It is used only when the student wishes to interrupt a recording and make a correction, since the Recording machine is put into Record automatically whenever this is required by one of the complex functions.

Conversation: This is a single-position key which initiates and advances the Conversation function.

Hold/Clear: The first position of this key causes both machines to pause as long as the key is held there; when the key is released the machines resume whatever motion was in progress before the key was pressed. The second position of this key (termed the "Panic Button") stops both machines, whatever they may be doing, puts the Recording machine out of record, and clears the control circuits.

The student occasionally uses three other controls: the Headphone Volume control (common variety), the Mode switch and the Microphone Control switch. The Mode switch has two settings, Active and Passive. The Microphone Control switch has three: "live" all the time, live except when both machines are going, live except when the Lesson machine is going.

6. William Stephenson - Biology:

Programming in biology, supported initially by funds from the grant, has been carried on without released time but with some support for clerical assistance. William Stephenson has been experimenting with different models of programming and is interested in finding out how far one has to program material to achieve high success on program and criterion items, yet still allow the student to utilize study skills already developed. Programming of problem material (gradually removing aids and letting students solve representative problems on their own), and programming of material designed to condition effective study behaviors in conjunction with a conventional text, are two of the areas of current interest. Sequences in general biology, genetics, cellular physiology have been programmed; future sequences will relate to laboratory material as well as text. The impact of self-instruction is described by Professor William Stephenson as follows:

> The preparation of programmed material for self-instruction has already saved me instructional time as well as increasing my teaching effectiveness. In my personal experience, the use of "spot programs" to cover areas of difficulty has been most successful. One such program dealing with a review of cell structure and function has been used in three different courses and a summer institute for high school biology teachers. Literally all of my programmed material has been reused and will continue to be used each year, with some revision and additions.
>
> I would like to continue to develop and use self-instruction material for my courses during the next few years. It would also be interesting and advantageous to utilize programmed material from other sources.
>
> In the future, I do not anticipate a desire for released time for programming or other self-instruction work. The availability of a student-secretary for 8 - 10 hours per week to help with the program revision, error frequency analysis, statistical analysis, and other clerical details is, however, extremely helpful.

In 1959 Earlham cooperated with Edward Kormondy of Oberlin College in an experiment involving programmed material in genetics: this experiment was repeated at Oberlin during 1960*. The results indicate that programmed material used for self-instruction gives better results than independent study using conventional text. Within experimental groups it was found that no significant differences existed between groups using conventional program material and groups using a "text" constructed by filling in the answers to the program and casting the statements in paragraph form. Although Holland's work at Harvard indicates that the nature of the program is crucial, this provides an interesting possible effect of programmed instruction on text construction, and implies that the ordering of the material is a crucial factor.

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*Experiment in Self-Instruction in General Biology, Edward J. Kormondy and Ellis L. Van Atta, the Ohio Journal of Science 62(1): 4, January, 1962

In order to determine roughly the effects of self-instruction on his own teaching procedure, Dr. Stephenson gave identical examinations to three successive genetics classes, beginning in 1959 and ending in 1961. Self-instruction material was introduced in 1960 and increased in 1961. The number of lecture sessions was reduced from about forty-five in 1959 to about thirty in 1960. Results indicate that student performance is not hampered by the shift in procedures.

Some additional field testing of the materials in Genetics used in the experiment mentioned previously is planned for the coming school year.

7. Hugh Barbour-Religion:
The work of the project stimulated a related experiment by Professor Hugh Barbour, who programmed the studying behavior of students relevant to the Bible by means of a series of questionnaires. These have been brought together in workbooks on both the Old and the New Testaments, and parts of the former will be published by Association Press. This use of programmed material to guide the student in his study of a piece of literature parallels an experimental approach of McCullough and Van Atta at Oberlin, although the programming itself differs. Some excerpts from a paper by Professor Barbour comment on the use of these workbooks:

> The response to our programs has seemed convincing; the students are mainly enthusiastic, though the burden of extra work piles up. For quizzes we have included one or more questions which present quotations unfamiliar to the student, but similar in thought to passages which they have studied, to let students apply the same principles (as learned in the programs - Ed) in new situations. Quiz results are good, but not statistically overwhelming. The most challenging problem remains: to let the student respond as fully and as appropriately as possible to what he is studying, even to the Bible itself ....

In another part of the same report, a comment is found on the style of the questionnaires:

> Each program is built around a single problem in reading: the localization of God in early Semitic thought, the sharing of man in natural forces of the cycle of seasons by Greek and Hindu worship, and so on. It has been fun to use in the questionnaires on Confucius, Lao Tze and the Koran, teaching styles corresponding to their own works: didactive, poetically allusive, or authoritarian.

8. Ansel Gooding, Charles Martin-Geology:
Beginning in the summer of 1962, some work in geology was begun which emphasized the visual self-instruction aspect of new media. This is described by Professor Ansel Gooding as follows:

> Some experimentation has been done with audio-visual programs

for self-instruction in Physical and Historical Geology. The technique involves the use of a machine synchronizing colored slides on a viewer with narration on tape. The Graflex machine has been used for our programs and is well suited for the purpose.

The programs consist of slides illustrating various geological features and their historical interpretation. Terminology and basic geological principles are stressed repeatedly.

Two kinds of programs have been prepared. One consists of slides of a variety of loosely related topics intended for comprehensive review at the end of the courses. Students have seen and had explained sometime during the course most of the slides used in these sets. The other group of programs are topical, aimed at getting across the elements of a hypothesis, or certain geological concepts and principles.

No controlled experimentaion has been done to determine the effectiveness of these programs. However, a sheet of paper was placed by the machine for recording of the frequency of use and student comments. These data show that the programs were used extensively, particularly before examinations, and comments were unanimously enthusiastic about the value of the programs. Some comments will be helpful in the revision of present programs and the planning of new ones. Many students urged the extensive expansion of such programs in the courses.

We expect to continue working on these audio-visual programs in Physical and Historical Geology next year, possibly keying to them sets of examination questions. The method has possibilities for programming materials for courses in Earth Science at the secondary school level, and also for more advanced college courses. More rapid progress in these areas will require additional geology department staff and funds.

9. M. Daniel Smith-Physics:

A program in Hydrostatics and Hydrodynamics, written by the coordinator of the project and test orginally at Harvard, was revised and used in Physics during the spring term. The data from this program has been processed; results indicate that the group profitied from the experience, but comparative data is lacking.

10. Other Related Projects: The work of the project stimulated similar work in several areas; one of these was Religion, already described, which received only secretarial help. Another was an experiment in teaching German, which is described by Professor Robert Brewster:

> In the Spring of 1960, with the encouragement of the Earlham Self-Instruction Center, I undertook the edition of an Ebacher inter-linear rapid reading text of the German 20th Century novel, abridge, entitled *Drei Kameraden*, by Erich Maria Remarque. Similar interlinear readers, with foreign language text and interlinear glossing of English equivalent words and phrases, phasing out each word or phrase after a certain experimental number of occurrences (ten in the case of German), had been edited by Keith Myers in Russian and Charles Matlack in Spanish at Earlham College.
>
> During the academic year 1960-61 I ran an experiment with two control groups of 25 students each, controlled as to class in college, sex, SAT Verbal scores and LAT (Linguistic Aptitude Test, Sapon, etc.,) scores. These students had no previous knowledge of German. The objective was to determine the performance of one group with Ebacher text and aural reinforcement (tape recording of text) as against the other group with Ebacher text only, in relation to passive vocabulary learning (German to English). The results, published in a report entitled *Vocabulary Learning through Reading German Prose (Ebacher Method) with or without Aural Reinforcement* showed no statistically significant difference between the two groups. The research and publication was entirely under Title VI, N.D.E.A. contract (above) with myself as principal investigator and the role of the Self-Instruction Center was consultative.

A certain amount of exploratory work in programming was also carried on by the English Department. Professor Wayne Booth, Chairman, comments on this:

> ...almost everyone in the Department is more convinced now than at the beginning of the grant of the potential usefulness of programmed instruction in certain aspects of English teaching.... But the development of such programs would require a tremendous amount of instructional time, and at present no one in the Department seems to have such amount of time clearly available.

Since existing materials are not suitable or adaptable to college level requirements, programmed instruction has not been of use in this department.

11. *Field Testing of Commercial Programs*: During the 1961-62 school year several programs developed elsewhere were used at Earlham: some of these were published commercially, others were being field tested by publishers (the reader is also referred to the previous use of a program in Genetics described in the detailed account of self-instruction in Biology). The reactions of students to these programs is in-

cluded in previous accounts by the coordinator relevant to this problem. It should be pointed out that with the exception of a program in use by the coordinator ("Analysis of Behavior") no programs developed outside the college are being used at present.

Part IV

Recommendations Regarding Future Projects

The following are some ideas set down by the present coordinator as recommendations regarding future projects similar to this.

General Procedure

(a) Determine by preliminary conferences areas within given subjects which are commonly treated in colleges and which could benefit from clarification and improved presentation. Identify that subset of those areas selected which can probably be covered adequately by programmed self-instruction (i.e. exclude motor behaviors, inculcation of "attitudes," non-verbal tasks in general).

(b) Determine as thoroughly as possible specific behavioral objectives to be achieved in these areas described in (a).

(c) Review existing programs to identify those which promise to fulfill objectives under (b) above, and arrange for the detailed evaluation and field testing of these according to procedures to be described subsequently.

(d) Arrange for the development of programmed learning sequences wherever the objectives determined in (b) above cannot be achieved through programs identified in (c), this development to be accomplished according to procedures described subsequently.

Testing of Existing Programs

I. Evaluation and processing:
  - A. Preliminary evaluation of:
    - (1) content
    - (2) auxiliary behaviors required or conditioned
    - (3) pre- and post-tests
    - (4) review and reference utility
  - B. Processing of programs for use:
    - (1) construction of pre- and post-tests where needed
    - (2) outline of nature of auxiliary behavior
    - (3) division of program into useful units
  - C. Utilization of program in:
    - (1) pilot study, using B and C under II below
    - (2) field testing, using all categories under II below
  - D. Data processing and analysis.

II. Data to be gathered regarding programmed materials:
  - A. Diagnostic battery, for information on interactions with individual differences.
    - (1) intelligence
    - (2) aptitude
    - (3) interests
    - (4) attitudes
    - (5) grades

B. Pre- and Post-tests
  - (1) pre-test made up of
    - (a) samples of pre-requisite behavior
    - (b) samples of target behaviors
  - (2) post-tests made up of same two categories
  - (3) transfer test made up of:
    - (a) behaviors similar to target behaviors
    - (b) learning situation requiring use of target behaviors (possible other progress).

III. Program Data:
  - A. Nature of errors
  - B. Location, number of errors
  - C. Student observations and reactions
  - D. Professor's observations and reactions

Procedures to be followed in developing programmed materials and new media for their presentation

The development of programs is a complex task, requiring deep understanding of both content and pedagogical problems involved. It calls for a considerable amount of clerical help for translating drafts into usable programs, processing data, and producing revised versions. Once individuals are selected who seem to have the requisite qualifications, the following procedure seems advisable:

- A. Pre-tests and post-tests representing both required and target behaviors should be constructed based on the detailed behavioral specifications contained in the report of the initial conferences held regarding the programming in this area.
- B. Initial construction of sequences to satisfy these objectives should proceed in units of one to two hundred frames, should be tried out on students in this process, and finally tried out on groups of five to ten students before the first stage of outside evaluation.
- C. These sequences should be reviewed by a subject matter expert and also by some one experienced in programming.
- D. The programmed sequence should then be tested as described in the preceding section.

Evaluation of Broad Effects

I. Drawing Comparisons with Conventional Approaches: In each subject matter area where programmed instruction and new media are to be used, information should be gathered concerning the following aspects of conditions which exist at present:

- A. Present methods of evaluation of learning, for incorporation into the evaluation processes of the project. Where possible, data should be collected before the project has an opportunity to affect the situation, especially where programs must be developed in the course of the project.

B. Present attitudes toward, and interests in, the subject matter in general, and in the particular limited area.
C. Present methods of approaching the learning task - lectures, demonstrations, text reading, independent study, and the like.

Control groups can be used, but it should be realized that the number of variables is too great to allow simple interpretations of outcomes.

The data so collected should be evaluated by the faculty members involved in the project. Their opinions concerning the meaning of the data, in view of their actual experience with the materials and media, will be reported. Quantitative data should become one of several sources of information used in passing judgments on the present and future values of programmed instruction in the educational process at this level.

Appendix A: Project Publications and Addresses by Project Personnel

Publications:

(1) 1-1 to 6-30, 1960

Alexander, H.W. and Smith, R.F., Elementary Statistics, A Self-Instruction Program. Richmond: Earlham College, 1960.

Barlow, J.A., "A New Form of the Pressey Multiple-Choice Board," Psychology Report, 1960, 6, 214.

Barlow, J.A., "Trends in the Use of Learning Machines," Current Issues in Higher Education, 1960. Washington: N.E.A., 1960 (p.255).

Barlow, J.A., Automatic Teaching: The State of the Art, edited by Eugene Galanter. (book review). Harv. Educ. Rev., 1960, 30, 164-66.

(2) 7-1 to 12-31, 1960

"The Earlham College Student Self-Instruction Project: A First Quarterly Report." In Lumsdaine, A.A. and Glaser, R. (eds.). Teaching Machines and Programmed Learning: A Source Book. Washington: N.E.A., 1960 (p.415-421).

Barlow, J.A., "The Earlham College Self-Instruction Program," Audio-Visual Communic. Rev., 1960, 8, 207-209.

Barlow, J.A., "Conversational Chaining in Teaching Machine Programs," Psychology Report, 1960, 7, 187-193.

(3) 1-1 to 6-30, 1961

Alexander, H., "Teaching Machine: Friend or Foe?" Indiana Mathematics, 1961, 13, 3-5.

Barlow, J.A., "Aspects of Teaching Machine Programming: Learning and Performance," Psychology Report, 1961, 11, 43-46.

Barlow, J.A., "Teaching Machines and Educational Philosophy," School and Society, 1961, 89, 201-202.

Barlow, J.A., "The Teacher and the Teaching Machine," A.I.D., 1961, 1. 5-6.

(4) 7-1, 1961 to 6-30, 1962

Gilpin, John, "A Tape Recorder for Instructional and Other Behavioral Research," JEAB, January 1962.

Gilpin, John, "Foreward" in Preparing Objectives for Programmed Instruction by R.F. Mager.

Gilpin, John, "Design and Evaluation of Instruction Systems," AV Communication Review, March-April 1962.

Smith, M. Daniel, "Some Considerations in Teaching Mathematics by Programmed Instruction," *The Mathematics Teacher*, May 1962.

Smith, M. Daniel, "A Science of Teaching" *Indiana Teacher*, May 1962.

Addresses by Project Personnel

(1) 7-1 to 12-31, 1959

John Barlow was a discussant on a panel on "Utilization of New Media for Instruction" at the annual meeting of the American Council on Education, October 8 and 9 in Washington, D.C.

At the Miami University Sesquicentennial Conference on Large Group Instruction, November 12-13, John Barlow presented a paper on "Teaching Aids for Individualizing Instruction."

(2) 1-1 to 6-30, 1960

Talks by John Barlow concerning the work of the project:

3-1 NEA-DAVI, Cincinnati, "The Earlham College Student Self-Instruction Project."

3-7 National Council on Higher Education (NEA) Chicago, "Teaching Machines and Programmed Learning."

5-13 Purdue Joint Conference, Lafayette, Indiana (ASCD, DAVI, ISLA) (discussion leader).

5-19 to 5-21 ASCD Conference, St. Louis, (seminar participant).

6-6 Alumni Seminar-Earlham College, "An Introduction to Programmed Learning."

(3) 7-1 to 12-31, 1960

Talks by John Barlow concerning the work of the project:

7-18 to 7-21 CASC Conference, Antioch College, Yellow Springs, Ohio, "An Introduction to Auto-Instructional Methods and Machines."

9-1 to 9-6 American Psychological Association, Chicago, "Aspects of Programming."

10-6 Trustees Conference, Earlham College, "Auto-Instruction at Earlham: Retrospect and Prospect."

11-3 Goshen College, Goshen, Indiana, "An Introduction to Auto-Instructiona Methods and Machines."

11-15 Ohio Psychological Association, Cleveland, "The Impact of Teaching Machines on Educational Philosophy."

(4) 1-1 to 6-30, 1961

3-25 Conference on Modern Trends in Mathematics for Secondary Schools, Ohio Wesleyan University, Howard Alexander and John Gilpin, "The History, Psychology, and Possibilities of the Use of Teaching Machines in Mathematics."

4-11 Indiana Association of College Business Managers, Hanover College, John Gilpin, "Purchasing for the Language Laboratory."

4-28 and 29 First Michigan Conference for Language Programmers, University of Michigan, John Gilpin, "A Versatile Apparatus for Audio Self-Instruction (the Polyaudio)."

Talks by John Barlow concerning the work of the project:

1-12 Psychology Club, Denison University, "Opperant Principles Applied to Teaching."

A.A.U.P., Denison University, "An Introduction to Auto-Instruction Methods and Machines."

1-19 Faculty Seminar, Ball State Teachers College, "Automated Instruction."

2-10 to 12 Fourth Annual Conference on the Behavioral Sciences and Education, Goddard College, "Self Education from the Viewpoint of Recent Developments in Reinforcement Theory."

2-20 American Society of Training Directors, Indianapolis Chapter, "Suggestions for Industrial Training Programs Growing Out of Lewinism and Skinnerian Psychology."

2-23 and 24 National Society of College Teachers of Education, Chicago, "The Teacher and the Teaching Machine."

3-2 Faculty Seminar, Wilmington College, "An Introduction to Auto-Instructional Methods."

3-24 Eighth Annual Audio-Visual Conference, Indiana State Teachers College, "Self-Instruction, Guided Instruction and the Role of the Teacher."

4-5 Faculty Seminar, Earlham College, "S.I.P., The Long View."

4-7 Indiana Psychological Association, Indianapolis, "The Schoolroom and the Skinner Box."

4-24 N.E.A.-D.A.V.I. Convention, Miami, Florida, "Using Programmed Learning in Teaching of the Old Testament."

4-26 West Texas School Study Council, Lubbock, Texas, "The Skinner Box in the Schoolroom."

5-11 Faculty group, Western Michigan University, "Self-Instruction Workshop."

5-12 Schoolmasters Club. University of Michigan Campus, "Teaching Machines and Programmed Learning."

(5) 7-1, 1961 to 7-1, 1962

M. Daniel Smith addressed a convention of school administrators at Ohio University on two successive days in July, once on the psychological foundations of programmed instruction and once on the applications of programmed instruction to educational problems. He also attended the special convention of the *Committee for the Advancement of Small Colleges* in Canton, Ohio (*Malone College*) where he addressed the convention on the subject of programmed instruction and teaching machines at the college level.

John Gilpin and M. Daniel Smith attended the yearly *Convention of the American Psychological Association* in September, where the former gave a paper at a symposium moderated by Kalmer Stordahl of the Office of Education. Both also addressed the DAVI Convention at Kansas City in March, the latter describing the self-instruction course in Russian and the former speaking on the subject of educational objectives.

Other addresses by M. Daniel Smith: the yearly convention of the *Indiana State Teachers Association* on the subject of programmed learning; by proxy, the annual fall meeting of the *AETS* in New York as a reactant in a discussion of automation. He was a discussant at a panel on Independent Squdy at the yearly *Convention of the American Association for Higher Education* in Chicago in March; he also attended the *Conference on Theory for the New Media in Education* at the Kellogg Center for Continuing Education at Michigan State University in March, and represented Earlham College at a convention of representatives of the *Great Lakes Association of Colleges* (this was called for the purpose of discussing a proposed project for the use and development of programmed instruction and new media throughout the Association). He also addressed the assembled summer session of *Indiana State College* in Terre Haute.

Appendix B: Personnel Connected with the Project

(1) 7-1 to 12-31, 1959

John A. Barlow, Coordinator and Research Director, full-time during summer, 3/4 time during school year.

John B. Gilpin, Technical Associate, full-time.

Robert Warner, Shop Technician, 3/4 time.

Sonya Zegarra, Clerical Assistant, full-time.

M. Keith Myers, Assistant Professor of Modern Languages, full-time one summer month, 1/2 time fall semester, Russian.

William E. Stephenson, Associate Professor of Biology, 1/2 time for fall semester, Genetics.

Howard W. Alexander, Associate Professor of Mathematics, 1/4 time fall semester, Statistics.

Wayne C. Booth, Professor of English, 1/4 time fall semester, Freshman English.

W. Forrest Altman, Assistant Professor of English, 1/8 time fall semester, Freshman English.

Warren Staebler, Professor of English, 1/8 time fall semester, Freshman English.

Leonard C. Holvik, Professor of Music, full-time one summer month, Introduction to Music.

Hugh Barbour, Assistant Professor of Religion, (Clerical assistance only provided by Project) Old Testament.

(2) 1-1 to 6-30, 1960

Howard W. Alexander, Associate Professor of Mathematics, 1/4 time.

John A. Barlow, Coordinator and Research Director, 3/4 time.

John B. Gilpin, Technical Associate, full-time.

Charles Matlack, Associate Professor of Modern Languages, 1/2 time.

M. Keith Myers, Assistant Professor of Modern Languages, 1/2 time.

Nora Scott, Instructor in Modern Languages, 1/4 time.

Roland F. Smith, Professor of Mathematics, 1/4 time.

Robert Warner, Shop Technician, 3/4 time.

Sonya Zegarra, Clinical Assistant, full-time.

(3) 7-1 to 12-31, 1960

Gerald Bakker, Assistant Professor of Chemistry, 1 summer month plus 1/6 released time for 6 months.

John A. Barlow, Coordinator and Research Director, 2 summer months and 3/4 time released from teaching during the school year.

Theodor Benfey, Professor of Chemistry, 1/6 released time for 6 months.

Charles Deardorff, Assistant Professor of Modern Languages, 1/2 time.

Leigh Gibby, Associate Professor of English, 2 summer months.

John B. Gilpin, Technical Associate, full-time.

James McDowell, Assistant Professor of Psychology, 1 1/2 summer months.

Lauretta Mosier, Assistant Professor of Modern Languages, 1 summer month.

M. Keith Myers, Assistant Professor of Modern Languages, 2 summer months and 1/2 time.

Jane Paxton, Administrative Secretary, full-time.

Wilmer Stratton, Assistant Professor of Chemistry, 1/6 released time for 6 months.

Robert Warner, Shop Technician, 3/4 time.

Howard Alexander, Associate Professor of Mathematics, Statistics.

Hugh Barbour, Assistant Professor of Religion, Old Testament.

Leonard Holvik, Professor of Music, Introduction to Music.

Charles Matlack, Associate Professor of Modern Languages, Elementary Spanish.

Roland Smith, Professor of Mathematics, Statistics.

William Stephenson, Associate Professor of Biology, Genetics.

(4) 1-1 to 6-31, 1961

John A. Barlow, Coordinator and Research Director, 3/4 time released from teaching during school year.

Charles Deardorff, Assistant Professor of Modern Languages, 1/2 time.

John B. Gilpin, Technical Associate, full-time.

M. Keith Myers, Associate Professor of Modern Languages, 1/2 time.

Jane Paxton, Administrative Secretary, full-time.

Robert Warner, Shop Technician, 3/4 time.

Earlham Faculty involved in project-related work:

Howard Alexander, Professor of Mathematics

Hugh Barbour, Associate Professor of Religion.

Ansel Gooding, Associate Professor of Geology.

Lauretta Mosier, Assistant Professor of Modern Languages.

William Stephenson, Associate Professor of Biology.

(5) 7-1, 1961 to 6-30, 1962

M. Daniel Smith, Coordinator.

Gemma Smith, Secretary.

John Gilpin, Research Associate.

*Robert Warner, 3/4 time, Shop Technician.

*M. Keith Myers, 1/2 time plus full-time for 2 months in summer.

Theodor Benfey, 1/3 time, Professor of Chemistry.

Wilmer Stratton, 1/3 time, Assistant Professor of Chemistry.

Gerald Bakker, 1/3 time, Assistant Professor of Chemistry.

Leonard Holvik, 2 summer months, Professor of Music.

*Charles Matlack, 1/2 time, 1 summer month, Associate Professor of Modern Languages.

*Lauretta Mosier, full-time, 2 summer months, Assistant Professor of Modern Languages.

*Reyes Carranza, $200/month, part-time, full year.

*Teoman Sipahigil, 3 summer months.

*Jean Sipahigil, 1 month, part-time.

*Rowena Warner, part-time all year, about 40 hours/month.

*Indicates work related to Russian and/or Spanish projects.

*Arlene Myers, part-time, all year, about 40 hours/month.

Dianne Kuhn, about 15 hours/month.

Faculty:

HOWARD WRIGHT ALEXANDER (1952) Associate Professor of Mathematics. A.B., 1933; A.M., 1934; University of Toronto; Ph.D. Princeton University, 1939.

GERALD ROBERT BAKKER (1959) Assistant Professor of Chemistry. A.B., Calvin College, 1955; Ph.D., University of Illinois, 1959.

HUGH BARBOUR (1953) Assistant Professor of Religion. A.B., Harvard College, 1942; B.D., Union Theological Seminary, 1945; Ph.D., Yale University, 1952.

JOHN A. BARLOW (1957) Associate Professor of Psychology and Coordinator of Self-Instruction Project. A.B., Oberlin College, 1949; Ph.D., Duke University, 1952.

OTTO THEODOR BENFEY (1956) Professor of Chemistry. B.S., 1945; Ph.D., 1947, University College, London; Columbia University, 1947-1948.

WILLIAM M. FUSON (1946) Professor of Sociology and Academic Assistant to the President. A.B., 1936; A.M., 1938, University of Kansas, Ph.D., University of Wisconsin, 1941.

JOHN B. GILPIN (1959) Research Associate for Self-Instruction Project. B.S., Dickinson College, 1958.

ANSEL M. GOODING (1951) Associate Professor of Geology. A.B., Augustana College, 1949; M.S., 1951; Ph.D., 1957, State University of Iowa.

LEONARD C. HOLVIK (1949) Professor of Music. S.B., 1940; A.M., 1942, candidate for Ph.D., Harvard University; Ford Foundation Faculty Fellow, 1954-55.

CHARLES W. MATLACK (1954) Associate Professor of Modern Languages. A.B., Haverford College, 1947; A.M., Middlebury College, 1949; Ph.D., University of New Mexico, 1954.

LAURETTA C. MOSIER (1934) Assistant Professor of Modern Languages. A.B., 1919; A.M., 1921, University of Wisconsin.

*Indicates work related to Russian and/or Spanish projects.

M. KEITH MYERS (1957) Assistant Professor of Modern Languages. A.B., University of Chicago, 1943; A.M., 1947; Ph.D., 1955, University of Illinois, Middlebury College, University of Paris.

M. DANIEL SMITH (1961) Coordinator of Self-Instruction Project and Assistant Professor of Education. A.B., Dartmouth College, 1948; M.M., University of Michigan, 1950; Ed.M., 1958; Ed.D., 1961, Harvard University.

ROLAND FREDERICK SMITH (1959) Professor of Mathematics. A.B., Oberlin College, 1939; M.S., University of Pennsylvania, 1946; Ph.D., Syracuse University, 1955.

WILLIAM K. STEPHENSON (1954) Associate Professor of Biology. A.B., Knox College, 1950; Ph.D., University of Minnesota, 1955.

WILMER J. STRATTON (1959) Assistant Professor of Chemistry. A.B., Earlham College, 1954; Ph.D., Ohio State University, 1958.

LAURENCE E. STRONG (1952) Professor of Chemistry. A.B., Kalamazoo College, 1936; Ph.D., Brown University, 1940.

Consultants:

(1) 7-1 to 12-31, 1959

John Blyth, Professor of Philosophy, Hamilton College.

Donald Bullock, Research Psychologist, Institute of the Pennsylvania Hospital.

Robert E. Corrigan, Director, Corrigan and Associates, Industrial Consultants.

Charles Ferster, The Institute of Psychiatric Research, Indiana Medical Center.

James Holland, Research Fellow, Harvard University.

Fred S. Keller, Professor of Psychology, Columbia University.

Douglas Porter, Instructor of Education, Harvard University.

(2) 1-1 to 6-30, 1960

Donald Bullock, Research Psychologist, Institute of the Pennsylvania Hospital.

Joseph Ebacher, Assistant Professor of Romance Languages, Xavier University.

Robert Glaser, Professor of Psychology, University of Pittsburgh.

2

James Holland, Research Fellow, Harvard University.

Idabelle Hoose, Assistant Professor of Psychology, Kent State University.

Fred S. Keller, Professor of Psychology, Columbia University.

Douglas Porter, Instructor in Education, Harvard University.

Devra Rowland, Harvard University Press

(3) 7-1 to 12-31, 1960

Charles Ferster, Institute of Psychiatric Research, Indiana Medical Center.

Thomas F. Gilbert, Associate Professor of Psychology, University of Alabama.

Fred S. Keller, Professor of Psychology, Columbia University.

Charles W. Slack, Educational Design of Alabama, Tuscaloosa, Alabama.

Loche Van Atta, Associate Professor of Psychology, Oberlin College.

Jay A. Young, Professor of Chemistry, King's College.

(4) 1-1 to 6-30, 1961

Harold Coppock, Associate Professor of Psychology, Arizona State University.

Joseph Ebacher, Assistant Professor of Romance Languages, Xavier University.

Thomas F. Gilbert, Associate Professor of Psychology, University of Alabama.

Joseph Mayer, Professor of Mathematics, Western College for Women.

Douglas Porter, Instructor in Education, Harvard University.

Jay A. Young, Professor of Chemistry, King's College.

(5) 7-1, 1961 to 7-1, 1962

James Holland, Research Fellow, Harvard University.

Appendix C: Status of Short Programs in Chemistry and Biology

I. Chemistry:

Project: To develop a series of programs dealing with chemical structures, of use particularly in the teaching of organic chemistry. There are a number of topics basic to the development of organic chemistry which are not very significant in themselves but need to be mastered in order to simplify the later discussion of chemical systems. Examples are the writing of electronic structures, the computation of charges on different atoms in the molecule, the unambiguous naming of organic compounds, the writing of the structures of all molecules with the same molecular formula, that is, containing the same number and kinds of atoms, but arranged in different ways. The proper procedure for carrying out such assignments requires very careful following of stepwise directions. Such directions are usually only imperfectly learned through lecture presentations or the reading of a textbook. It was thought that programmed instruction in these topics may be able to transmit the proper steps in a way assuring mastery of the simpler stages before more complicated problems are attempted.

1. The Systematic Naming of Alkanes (24 frames): Written, checked and tested Spring 196[illegible].
   Error rates on 46 students analyzed.
   Material discussed with new College project director (Dan Smith).
   Modified to be essentially independent of previous chemical knowledge.
   Mimeographed in revised form (31 frames) Spring 1962.
   Tested in third-term freshman class April 1962 (44 students).
   Material currently being analyzed.
   Answers to examination questions are also being analyzed.

   The original program was mentioned in an artical on programming in chemistry by Jay A. Young, King's College, Wilkes-Barre, Pennsylvania, in the *Journal of Chemical Education*, 38, 463, (1961). About 37 requests for copies were received, and programs sent. Professor Joan Jones of the University of Illinois, Navy Pier, Chicago, used the program in a freshman class of 23 students, mainly nurses, and sent error rates. In general they followed those obtained here, though the average was higher. Strangely, a higher proportion of students in Chicago gave correct answers to the most difficult questions than students here.

2. Naming of Alkanes and Other Aliphatic Hydrocarbons (28 frames): Written and checked Spring 1961; revised Winter 1962 and mimeographed. Will be tested within a week or two in third-term freshman class. This program will be sent to all persons who wrote for programs in connection with the Jay Young article.

3. Naming of Alkyl Halides (12 frames): Written, checked, revised and mimeographed Winter 1962. To be tested this Spring.

4. Naming of Alcohols (19 frames): status same as (3).

5. Naming of Aldehydes and Ketones (21 frames): status same as (3). This program attempts to use as little explanation as possible, teaching the naming rules almost exclusively by means of examples.

6. Naming of Carboxylic Acids (12 frames): similar to (5).

7. Construction and Naming of Organic Esters: In beginning stages. This program will attempt instruction in common naming and systematic naming in the same program, as very similar procedures are followed.

(Note: Programs 1-7 complete the planned programs in systematic aliphatic nomenclature.)

8. The Calculation of Formal Charges and the Writing of Electronic Formulas (87 frames): Written, checked, revised and mimeographed, Winter 1962. Tested by a group of 15-16 juniors and seniors in chemistry courses, mainly as review. Error rates 1.6 per student for part A (formal charge calculations), 1.5 errors per student in part B (electronic formulas). Errors were marked on answer sheets by students and checked by me. No attempt was made systematically to find errors not indicated by students.

   The program was given in April 1962 to 23 freshmen in their first term of college chemistry. A group of students with excellent high school background in mathematics and science, they had taken an accelerated mathematics course first term, a physics course second term. The procedures discussed in the program have not yet been discussed in class. The error rates were 1.5 per student in part A, 2.2 per student in part B.

   An unannounced test on the program material was given a week after the program was returned. The formal charge calculations were answered correctly by 21 out of 23 of the students, a phenomenal change from the 50% or less who learn to do this through lecture presentation and a problem assignment.

   The writing of electronic formulas was less successful. In one question 14 students gave correct answers, the other 9 all gave the identical wrong answer. The program obviously needs revision to avoid this error. Attached is a copy of the "post-test" together with tallies and wrong responses. An examination, in part covering the programmed material was given April 30 and is being analyzed.

9. The Computation of Isomer Numbers and the Writing of Structures of Isomeric Alcohols (app. 20 frames): The number of chemically different substances with the same molecular formula (cf. introductory comment) rises markedly with increasing carbon content. Thus there is one alcohol CH_3OH, one C_2H_5OH, two C_3H_7OH, four C_4H_9OH, seventeen with formula $C_6H_{13}OH$, thirty-nine with formula $C_7H_{15}OH$ etc. A program which systematically calculates the total number of isomers and

provides a way of writing down their structural formulas was worked out, based on the article by H.R. Henze and C.M. Blair, Journal American Chemical Society, 53, 3077 (1931). The program is currently being checked by a student. It is hoped to extend this approach to the writing of the formulas of the isomeric saturated hydrocarbons though it seems a much harder job. The alcohol program applies to any class of compounds consisting of saturated hydrocarbons with one hydrogen replaced by an atom other than hydrogen or a group other than an alkyl group.

1. Oxidation-Reduction Equations (60 frames): Designed to acquaint the student with the concepts of oxidation state and oxidation-reduction reactions, and to help the student develop some proficiency in balancing redox reactions in ionic form using an oxidation number method. The program assumes a general elementary knowledge of atomic and molecular structure, chemical reactions and equations, and the writing of essential ionic equations.

The program was written and given class trial with 30 sophomores during Spring 1961. Error rates were analyzed and the program was revised and remimeographed. The revised form has recently been tested (including pre-and post-tests) with 25 sophomores and 75 freshmen, and the results are now being analyzed. With the sophomore group the overall error rate dropped from 9% to 7%, but perhaps of greater significance, the error rate on the last ten questions dropped from 15% to 4%. Not unexpectedly, the error rate for the freshman test group appears to be considerably higher, suggesting that if the program were to be used extensively for freshmen it would need to be modified.

2. The Writing of Ionic Equations (70 frames): Designed to help the student become familiar with the nature of ionic reactions and the use of essential ionic equations to describe these reactions. A wide variety of examples are used and the program includes memorization of some solubility and ionization rules. This program would logically precede the above program on oxidation-reduction; these two programs together should provide a good foundation for practical use of equations in inorganic and analytical chemistry. The program assumes a general elementary knowledge of (1) chemical reaction, equations and formulas, (2) ionic and covalent bonding, (3) ionization and hydrated ions, and (4) acids, bases, and salts.

This program was written, tested by several students and faculty, and extensively revised. It is now ready for duplication and class testing.

3. Equivalent Weight and Normality (80 frames): Designed to teach the concepts of equivalent weight and normality and to provide in the application of these concepts, particularly to the calculations of volumetric analysis. Numerous examples are taken of both acid-base and oxidation-reduction reactions. The program assumes a general knowledge of chemical reactions, redox reactions and equations, and elementary volumetric analysis.

The program was written and given a class trial in the Spring of 1961. On the basis of those results and faculty comments, it was extensively revised, tested with several students, and further revised. It is now ready for duplication and further class trial. (This program is a good example of the benefits resulting from adequate testing and revision. As a result of successive evaluations, the program has gone through a series of modifications and in the process the author has clarified his thinking considerably on the subject matter of the program!)

4. Colligative Properties of Solutions (145 frames): Designed to help the student become familiar with the fundamental aspects of colligative properties, the derivations of some useful relationships, and the use of these relationships in solving typical problems of interest to chemists (including extension to ionic solutions). The development is essentially non-thermodynamic. The program assumes a general elementary knowledge of the states of matter, the properties of gases, equilibrium, and molecular weight.

   The program is now in process of being mimeographed and will be given a class trial this Spring.

5. Use of Logarithms in Chemistry (50 frames): Although all students taking college chemistry have been exposed to logarithms in high school, many students have trouble in working problems involving logarithms. This program provides a brief review of exponents, bases, and logarithms, and then provides practice in the use of log tables.

   The program was prepared and given class trial during Spring 1962. Error rates have not yet been analyzed. Student comments, however, were quite enthusiastic.

Programs: Chemical Equations (33 frames plus summaries) - This program was written to teach the student how to use chemical formulas and how to balance simple equations by inspection. No background other than general physical science is required. The program has been evaluated and completely rewritten. On the basis of further use this spring, the program will be rewritten again, and tested with a class of 100 beginning chemistry students in the fall of 1962. The basic ideas of this program (but not the program itself) were used successfully in an hour and twenty minute presentation to a class of sixth graders.

Atomic Theory (84 frames): This is the first part of a larger program designed to enable a student to handle the concepts of the Atomic Theory, to work simple stoichiometry problems, and to understand the historical background of these concepts. It is assumed that "Chemical Equations" will be worked through by the student before he does this program. The program has been evaluated by chemistry faculty and several students, and will be rewritten and hopefully completed for testing in the fall of 1962.

Experiment Three (21 frames): The program covers the establishment of the identity of a substance by the method of mixture melting points. It has already been rewritten twice after evaluations by students and faculty. With some modification it will be ready for use next fall and good test data should be obtained. The analysis of student answer sheets indicated clearly that error rates and missed frames gave only clues as to the modifications needed.

Study Sheets: Several additional study sheets, such as that prepared for the biochemistry class, have been written this spring. These are built not on the basis of questions and answers but as guides to material which the student is then expected to dig out for himself.

Future Programs: It is hoped that the proper test data on the above programs can be obtained next year, and the writing of programs on topics such as "Elements-Compounds-Mixtures," "Operational Definitions" and the "Electrical Nature of Matter" can be accomplished.

II. Biology:

General Biology:

Laboratory preparatory exercises - item identification and exposition. These use a modified "flash card" technique for facilitating rapid learning.

ca 400 items

Genetics:

Identification exercises (as above) covering the subject matter of the entire course.

ca 400 items

Problems - a set of genetics problems in programmed format covering the basic principles of genetics.

ca 300 items

Probability - an introduction to the basic principles of probability theory as applied to genetic systems.

ca 50 items

Application of Probability to the Analysis of Family Histories.

ca 50 items

Independent Reading Aids - A set of programs designed to facilitate the reading and comprehension of research articles and summary reports.

ca 200 items

Physiology:

Cell Structure and Function - This program has been used in several courses with success.

ca 200 items

pH - A brief, long-step program which covers the basic principles of pH.

20 items

Osmotic Pressure - A brief, long-step program which covers simple principles and calculations involved in the application of osmotic considerations to biological systems.

30 items

Experiments with Self-Instruction Material:

"A Self-Instruction Experiment with Genetics Material in the General Biology Laboratory," by William Stephenson and Judy Doty (1959).

Appendix D: Samples of Selected Programs

H.W. Alexander - R.F. Smith

I. Statistics

12.16 When each value in the set (3, 5, 11, 15) is doubled, we obtain the set (6, 10, 22, 30). From the table at the right we find, for this set, $\Sigma X =$ ______, $\Sigma X^2 =$ ______, and from these the variance is $\frac{1}{n-1}\left[\Sigma X^2 - \frac{(\Sigma X)^2}{n}\right] =$ ______.

X	X^2
6	36
10	100
22	484
30	900

68, 1520, 121.33.

12.17 The variance of the set (3, 5, 11, 15) is 30.33, while that of the set (6, 10, 22, 30) is 121.33, four times as great. This illustrate the general principle that if each value in a set is ______ by a constant k, its variance is ______ by K^2.

Multiplied, multiplied.

12.18 The variance of the set (3, 5, 11, 15) is 30.33, and its standard deviation is $\sqrt{30.33} = 5.51$. The variance of the set obtained by doubling each value in the above set, namely (6, 10, 22, 30), is $121.33 = 4 \times 30.33$. Hence the standard deviation of the latter set is $\sqrt{121.33} = \sqrt{4} \times 30.33 = \sqrt{4} \times \sqrt{30.33} =$ ______.

11.02.

12.19 The standard deviation of the set (3, 5, 11, 15) is 5.51, while that of the set (6, 10, 22, 30) is 11.02. This illustrates the general principle that if each value in a set is multiplied by k, the standard deviation is multiplied by ______.

k.

12.20 If each value in a set is increased by k, the mean of the set is ______ and the standard deviation is ______.

Increased by k, unaltered (or a similar expression).

12.21 If each value in a set is multiplied by k, the mean of the set is ______ and the standard deviation is ______.

Multiplied by k, multiplied by k.

II. Dr. M. Keith Myers, ДИАЛОГИ, Разговор первый

*[аДИН] 1. [ДОБ рə ИI УТ рə.]
один 1. Доброе утро.
one good morning

[ДВА] 2. [ДОБ рə ИI УТ рə.]
два 2. Доброе утро.
two good morning

[аДИН] 1. [маЙА фаМИ ли йə ________.] [КАК ВА шə фаМИ ли йə?]
один 1. Моя фамилия ________. Как ваша фамилия?
one my last-name "is" [how] what "is" your last-name

[ДВА] 2. [маЙА фаМИ ли йə ________.]
два 2. Моя фамилия ________.
two my last-name "is"

[аДИН] 1. [пəф та РИ тI, па ЖАЛ стə.] [КАК ВА шə фаМИ ли йə?]
один 1. Повторите, пожалуйста. Как ваша фамилия?
one -repeat please- [how] what "is" your last-name

[ДВА] 2. [маЙА фаМИ ли йə ________.]
два 2. Моя фамилия ________.
two my last-name "is"

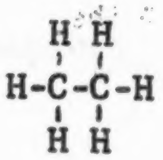
[аДИН] 1. [спаСИ бə.] [НУ, дə сь ви ДАНЬ йə.]
один 1. Спасибо. Ну, до свиданья.
one thanks well [till the-meeting] good-bye

[ДВА] 2. [дə сь ви ДАНЬ йə.]
два 2. до свиданья.
[till the-meeting] good-bye

III. O. T. Benfey

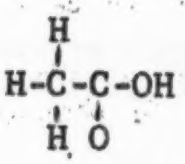
(1) The Systematic Naming of Carboxylic Acids

6-1



$H\text{-}\overset{H}{\underset{H}{C}}\text{-}\overset{H}{\underset{H}{C}}\text{-}H$

ethane



$H\text{-}\overset{H}{\underset{H}{C}}\text{-}\underset{O}{C}\text{-}OH$ or CH_3CO_2H

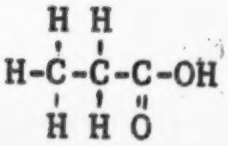
ethanoic acid

$CH_3CH_2CH_3$

propane

____

propanoic acid



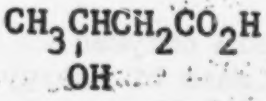
$H\text{-}\overset{H}{\underset{H}{C}}\text{-}\overset{H}{\underset{H}{C}}\text{-}\underset{O}{\overset{}{C}}\text{-}OH$ (or $CH_3CH_2CO_2H$ or $C_2H_5CO_2H$)

6-2 Pentanoic acid is ______________

$CH_3CH_2CH_2CH_2CO_2H$

(NOT $C_5H_{12}CO_2H$, the acid carbon is part of the original pentane)

6-3 3-hydroxybutanoic acid is ______________



$CH_3\underset{OH}{C}HCH_2CO_2H$

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Prepared in connection with a research project supported in part by a grant from the United States Office of Education, Department of Health, Education and Welfare (Grant No. 7-12-026.00)

W. Stephenson

IV. Cell Program A

Cell A-2

	Item	Answer
16.	The genetic material is largely confined to the ______ of the cell.	nucleus
17.	Most of the metabolic activity of the cell (respiration, photosynthesis, etc.) occurs in the ________.	cytoplasm
18.	Vacuoles are fluid filled structures within the _________ of the cell.	cytoplasm
19.	Vacuoles are filled with _________.	fluid, liquid
20.	Fluid filled structures in the cytoplasm of a cell are termed ________?	vacuoles
21.	Chloroplasts are a type of plastid in the cytoplasm of plant cells which function in the process of _______?	photosynthesis
22.	Plastids are large (usually greater than 2 microns) regularly shaped structures in the __________ of plant cells.	cytoplasm
23.	Chloroplasts are a type of large regularly shaped structures called ___________.	plastids
24.	A type of plastids found in plant cells?	chloroplastids (chloroplasts)
25.	A fluid filled structure in the cytoplasm?	vacuole
26.	Mitochondria are small round or thread-like bodies (usually 1-3 microns long) in the __________ of cells.	cytoplasm
27.	Mitochondria contain enzymes which are important in the release of energy by respiration. Does respiration take place in the nucleus or cytoplasm?	cytoplasm

V. W. J. Stratton

EQUIVALENT WEIGHT AND NORMALITY

C. Oxidation-Reduction Reactions

27. The equivalent weight of any substance which is oxidized or reduced is the weight which gains or loses one mole of __________.

---

electrons

---

28. Taking a simple example first, the oxidation of metallic elements, the equivalent weights of the following metals are what fractions of their atomic weights?
    - a. Na ($\rightarrow Na^{+} + e^{-}$)
    - b. Mg ($\rightarrow Mg^{++} + 2e^{-}$)
    - c. Al ($\rightarrow Al^{+++} + 3e^{-}$)

---

a. 1, b. 1/2, c. 1/3

---

29. In the reaction, $2Na + Cl_2 \rightarrow 2NaCl$, the equivalent weight of sodium is equal to its atomic weight, and the equivalent weight of chlorine is what fraction of the molecular weight of chlorine? __________.

1/2 (2 Cl atoms, each gains 1 electron)

---

30. The changes are often more conveniently expressed as changes in oxidation state. An increase of one in the oxidation state corresponds to what electron change? __________.

---

loss of one electron

---

31. Therefore the equivalent weight of an element (in a given reaction) is the atomic weight _____ (divided or multiplied) by the change in oxidation state for that element.

---

divided

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Prepared in connection with a research project supported in part by a grant from the United States Office of Education, Department of Health, Education and Welfare (Grant No. 7-12-026.00)

2.06 Now solve this equation for p
divide by A

p+ ________ - p - ________ = 0
then $\rho g\Delta y$ = ________ ___

$$pA + \rho gA\Delta y - (pA + \Delta pA) = 0$$

$$\cancel{pA} + \rho gA\Delta y - \cancel{pA} - \Delta pA = 0$$

$$\rho gA\Delta y - \Delta p\cancel{A} = 0$$

$$\rho g\Delta y = \Delta p \text{ or } \boxed{\Delta p = \rho g\Delta y} \quad \leftarrow \text{SOLUTION}$$

2.07 Apply this to the following question:
What is the difference in pressure between two points in a fluid which are "z" units different in depth?

$\Delta p = \rho gz$ (z takes the place of Δy)

2.08 Suppose one point is at the surface, and the other point is "d" units below the surface, and the pressure at the surface is "p_a;" what is the actual pressure (not just the difference) at the point "d" units below?

Actual pressure = $p_a + \rho gd$

You find the difference in pressure from the formula we derived, then add to the difference the pressure at the top point.

2.09 Branch: do this only if you missed the last one:

Pressure at point "1" is "q;" point 2 is "y" units below 1; what is the pressure at point 2?

$$p_2 = q + \rho gy$$

2.10 Consider figure 2: it shows three containers, each with the same fluid in them at the same depth. Each has a base of area "A". What is the force exerted on the base by the fluid in each of the cases?

Hint: (Use this if you don't know how to start.)
Calculate the pressure at the base in each; then calculate the force in each case using "A" for the area of the base:

$(p_a + \rho gh)A$ Same force on the base for all three.

Although there is a different amount of fluid in each, the force on the base in each case is the same because the pressure is the same; this is known as the Hydrostatic Paradox.

VII. Matlack, Mosier, Myers, Carranza, *Fónica Española*

**[ú-no] 1. [e-n‿español la létra "té" se pronúnsja sjém-pre
uno 1. En español la letra "t" se pronuncia siempre
one in^1 -- -- -- -- -- -- always^o

si-n‿as-pi-ra-sjó-n‿i kǫn la pún-ta đe la lén̲-gwa
sin aspiración y con la punta de la lengua
without aspiration and with -- tip of -- tongue

kǫ́n-tra lǫz đjén-tes su-pe-rjó-res, ez đe-sír,
contra los dientes superiores, es decir,
against the -teeth upper- [is to-say]
that is

ká-si kó-mo la "té"‿en la pa-lá-bra‿jn̲glesa "nutmeg."
casi como la "t" en la palabra inglesa "nutmeg."
almost like -- -- in^o -- word^o -- --

**[dǫs] 2. [kó-mo se pronúnsja sjémpre la "té"‿española?]
dos 2. ¿Cómo se pronuncia siempre la "t" española?
two how^o -- -- -- -- -- --

**[tres] 3. [ú-no-s‿ẹ-xém-plǫs sǫn: "fál-ta, fa-tál, pa-la-tál."]
tres 3. Unos ejemplos son: "falta, fatal, palatal."
three some^1 examples^1 are fault fatal palatal

H. Barbour

VIII. Bible

Questionnaire III: The Religion of David

.... Part III-A: Read through the story in II Samuel 6:- in your Bibles.

1. Around what object does the story in II Samuel 6:- center?

   The Ark of God (or Arkof the Covenant of the Lord: the word "Ark" means a box. Don't confuse this with Noah's Ark.

2. Who originated the Ark, and where? (cf. Numbers 10;33-36)

   Moses brought it with the Hebrews from Mount Sinai.

3. What did the Ark symbolize for the Hebrews?

   The presence of Yahweh. (It also symbolized the Covenant, but if there were stones in the Ark they stood for the mountain where God lived, just as much as they stood for the commandments God gave.)

4. Why is David described in II Samuel 6:5 as being "before the Lord" while he was making merry?

   He was in front of the Ark: ("the Lord" is Yahweh, who is here thought of as actually living in the Ark.)

5. In verse 14, where does David dance?

   In front of the Ark.

6. Where had David intended to take the Ark? (6:10)

   To the City of David (Jerusalem): cf. II Samuel 5:7.

7. Why is Jerusalem called the City of David in this story?

   He had just captured it (5:7); David now lived there: (5:9).

8. Who had been the previous inhabitants of Jerusalem? (cf. II Samuel 5:6)

   Jebusites (a Canaanite group)

9. Did Jebusites and Canaanites worship Yahweh? (cf. Joshua 9:1-2) To whom were their shrines dedicated?

   Most Canaanite shrines were dedicated to Baal, Adad or Astarte. The Fertility gods.

10. Why would Hebrews want to have the Ark in Jerusalem?

    By bringing the Ark there they would ensure Yahweh's presence there, so as to be able to make sacrifices to Yahweh in Jerusalem.